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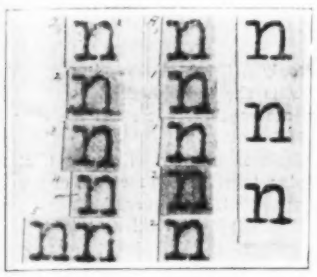


Fig. 1.—Comparison of disputed type with known specimen.

Fig. 2.—To prove ownership of this razor, which figured in murder trial, the document examiner had to decide whether the name was scratched on by defendant.

Fig. 3.—Original enlarged 12 times, compared with test specimen.

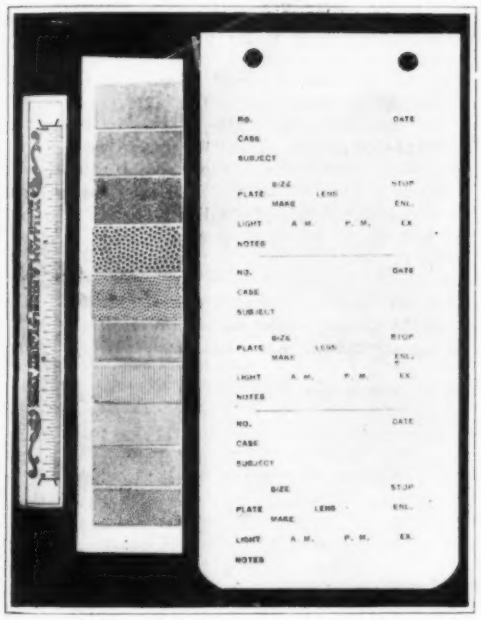


Fig. 4.—Measuring scale to photograph with object; tint scale for focusing; page from record book.

Fig. 5.—Abbreviation "Str" for "street." Upper sample threatening letter, two and three comparison standards. After four days' trial defendant pleaded guilty.

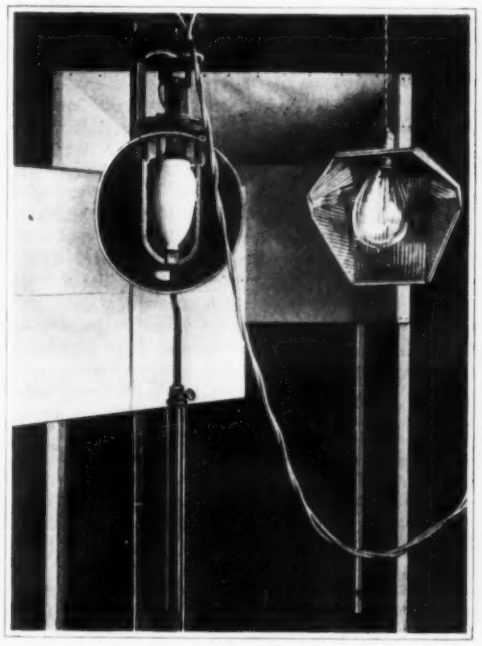


Fig. 6.—Lighting apparatus with arc lamp and adjustable 250 Watt Tungsten lamp with Frink reflector; hood placed around opening in using artificial light; white reflector with daylight.

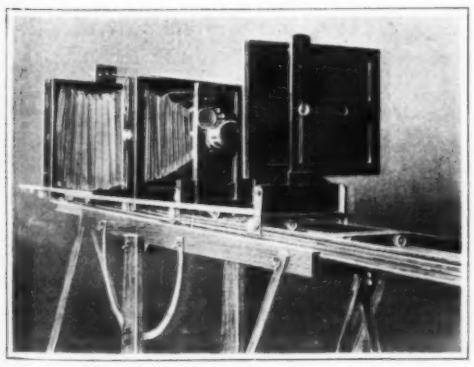


Fig. 7.—The document camera, with base and stand.

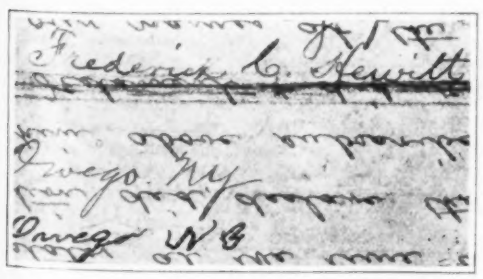


Fig. 8.—Transmitted light photograph, showing three different pens and three different inks were used.

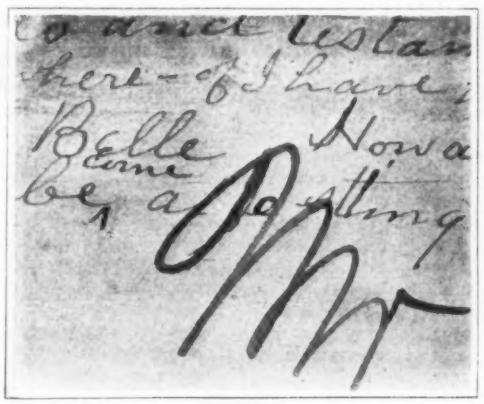
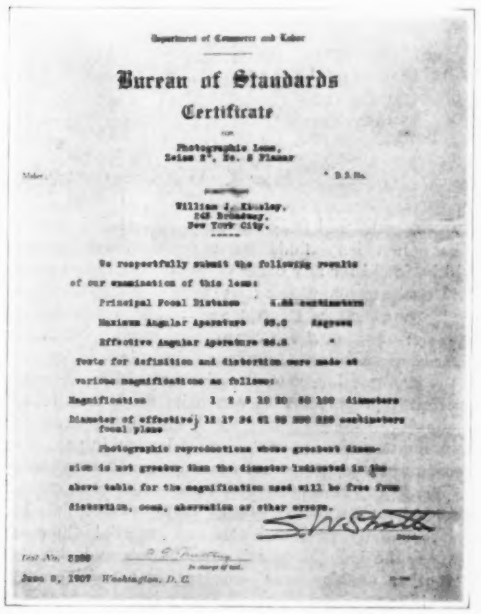


Fig. 9.—A Will Case. Enlargement of part of Fig. 11, showing body of letter was written after and over signature.



Department of Commerce and Labor

Bureau of Standards

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of

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Maker ... D.S.No.

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William J. Hinsley,
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We respectfully submit the following results of our examination of this lens:

Principal Focal Distance 4.86 centimeters
Maximum Angular Aperture 90.0 degrees
Effective Angular Aperture 86.8 "

Tests for definition and distortion were made at various magnifications as follows:

Magnification	1	2	5	10	20	50	100	diameters
Diameter of effective field	12	17	24	41	90	200	320	centimeters

Photographic reproductions whose greatest dimension is not greater than the diameter indicated in the above table for the magnification used will be free from distortion, coma, aberration or other errors.

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Director

Test No. 2200 By ... Assistant in charge of test.

June 9, 1907 Washington, D. C.

Fig. 10.—Lens certificate from Bureau of Standards.

DOCUMENT PHOTOGRAPHY AS USED IN THE COURTS.—[See page 308.]

Stellar Distribution and Movements*

What Determines the Arrangement of Stars in Space, and Their Motion?

By A. S. Eddington

THE last few years have brought to light many new facts in the field of astronomy, and it is opportune to look back and take stock.

It is believed that the great mass of the stars (excluding the Milky Way) is arranged in the form of a lens or bun-shaped system, in which our sun occupies a nearly central position, at least midway between the two flattened surfaces. The thickness of the lens, though enormous, is not so great as to prevent the telescope from detecting the absence, or, at any rate, a gradual thinning, of stars beyond when looking toward the poles of the Milky Way. When looking along the plane of the Milky Way, in the direction of the perimeter of the lens, the thinning out is much less marked, though probably not beyond the power of the telescope. Near the sun the stars appear to be distributed in a fairly uniform manner; in the remoter parts series of clusters forming the Milky Way are observed. As regards the galactic plane, two distinct phenomena (sometimes confused) have to be distinguished; firstly, the plane in which the clusters of the Milky Way are coiled, and, secondly, the median plane of the lens-like arrangement of the nearer stars.

The study of the movements of the stars has to be confined to the central system, and perhaps to the inner parts of it. The remarkable result is that the stars seem to move with a strong preference in two opposite directions in the galactic plane, as Kapteyn showed in 1905. The two streams seem to be more or less independent, but intermixed for the time being, and to move to and fro along a particular line; and it is a significant fact that this line lies in the galactic plane, suggesting a connection between the phenomena of stellar distribution and stellar motion, though it remains to be explained why there is a plane of symmetry in the one case and a line of symmetry in the other. The next noteworthy features are the moving clusters—groups of stars which, though widely separated in space, move with equal velocities in parallel paths. There is the Taurus cluster of forty members; the Ursa Major cluster, now known not to be confined to the one constellation, of thirteen known members; the Perseus cluster of seventeen helium stars; a very large ill-defined cluster in Scorpio, etc. In each case the members move with apparently identical velocities, ignoring, as it were, other stars interspersed between them. The peculiar movements have in many cases afforded means of detecting distances and absolute luminosity of stars far too remote for ordinary methods of measurement.

The stars of the Orion or helium type of spectrum stand out exceptionally. They do not share in the stream motion, have in fact little individual or systematic movement; many of them are of enormous intrinsic brilliancy and probably lie beyond that part of the universe generally considered; others tend to form moving clusters, which give out diffused nebulosity of enormous extent (Orion and Pleiades clusters). The strangest result is connected with the study of their spectral types. Stars had been arranged by their spectra in what astrophysicists believed to be successive ages of evolution, and stars of early types of evolution have much slower motion than those of later stages. It seems as if a star were born with no motion at all and gradually acquired a motion in the progress of time.

Proceeding to details, according to parallax measurements, a sphere of a radius of 95 billion miles (one million times the radius of the earth's orbit roughly) seems to contain seventeen stars, including our sun; a few members may be missing, but they can only be small. Those stars are rather tightly packed; seven of the seventeen are double stars, possibly a high proportion; in intrinsic luminosity they range from forty-eight times the luminosity of our sun down to one one-hundredth that value. Five of the seventeen are more luminous than the sun. Stars as bright as 10,000 suns exist in space, but are probably very rare. Comparing the stars of this sphere with others, it would appear that stars of the *M* type are abundant, but faint, and stars of the Orion *B* type very rare, but prominent because brilliant; the frequency figures deduced from star catalogues are misleading. Parallax measurements do not carry the astronomer far out into the universe; there are 300 stars of more or less trustworthy parallax, but that number contains many cases of parallaxes of 0.1 second and less. In order to go beyond the limits of parallax measurements, the astronomer had to examine statistics of magnitude and motion. This brings out the crowding of stars near the Milky Way, partly accounted for by the lens shape of the Universe. A peculiar distribution rule has long been known. In an unlimited Universe the number of stars of one magnitude, e. g., the eighth, should be four times as great as that of stars of the next magnitude above, i. e., the seventh (the brighter the stars, the lower is the figure denoting magnitude). The star ratio falls short of the theoretical value, however, at greater distance, especially in the polar direction of the galactic plane.

Probably at least half a million stars belong to the two star streams. When plotted on a globe the two streams converge to two points, not diametrically opposite one another, but 110 degrees apart. On the globe we may also mark the solar antapex, the direction in which all the stars appear to move in consequence of the solar motion through space. It is owing to this motion of the solar system that the favored directions did not appear exactly opposite, as they would from an absolute standpoint.

Streaming in two directions has now been detected in the radial motions by Hough and Halm and by Campbell. It is curious that the helium stars do not share in the stream motion, while those of the *A* spectral type, next to the helium stars in the order of evolution, show the streaming in its purest form. The anomaly might be explained by the great distance of these stars. As to clusters, Boss has pointed out that the Taurus cluster would appear globular in the distant future, while the stars of the Ursa Major and of the Perseus stream are according to Turner, nearly in the same plane. According to Hinks all the globular clusters are found in one hemisphere.

The most startling result of the most recent observations (long foreshadowed, however) is that stars of the later spectral type have larger motions than those of earlier types. In the Orion type the individual movement is only a third of what it will ultimately become. How is the individual motion to be accounted for? The assumption that stars are developed from a primordial matter not subject to gravity is unwelcome and also unnecessary. Suppose a star were formed by lumping together the meteors or gases of some portion of space. If a thousand stars were lumped together, their individual motions might cancel, and the resultant superstar might be at rest; similarly, the motions might cancel in a single star. It is more difficult to explain how the star acquires motion, and how clusters moving through space filled with stars not belonging to their system retain their equal and parallel motion. It is a necessary conclusion, that the forces which produce the individual velocities are nearly constant over large volumes of space, i. e., large with regard to the distances from their neighbors. That means that the central gravitational attraction of the Universe, and not the casual interference of neighbors, has been effective, and this agrees with calculations. The nearest neighbor of our sun is α Centauri, on which the sun acts with a force which would take 400 million years to produce a velocity of one kilometer per second. In close approach the velocity would temporarily be much greater; but there would be a subsequent loss on receding, and the effect of such an encounter would only be a slight change in the direction of motion.

On the other hand, a resultant force of all the matter of the Universe seems adequate to produce stellar motion. The Universe, of course, does not act as if it had a center of gravity. A rough idea of the force can be gained from a comparison of light and gravitation. Both vary as the inverse square of the distance, and roughly the attraction toward any part of the sky may be measured by the total light of the sky at that part. That total light is estimated at 2,400 stars of the first magnitude, and the total gravitation would probably bear the same ratio to that of a star of the first magnitude. Owing to the central position of the sun the pull is pretty uniform in all directions, and there is little resultant force, which would, however, be considerable on an eccentrically placed star. According to another suggestion, due to Halm, the Orion stars are slow, not because young, but because they are heavy. A third possibility is that the great distance of the Orion stars was the cause.

* Report, adapted from *Engineering*, of a paper read before the British Association.

The Iron-Ore Supplies of the World*

How Shall We Meet Future Demand?—An Inventory

By J. W. Gregory, D.Sc., F.R.S., Professor of Geology at the University, Glasgow

IRON may be said to be the material in which modern civilization chiefly finds its expression. Substitutes could be found for any other of the metals in use or the world could go on without it; even if our coal supply failed, other sources of heat and power would still be available: but modern civilization would inevitably wither in a serious iron famine, as cheap iron is required for the construction of the appliances used in the cultivation and preparation of our chief foods and in the manufacture of our clothing; it is also indispensable as a building material in our modern cities and in providing the means of rapid transport which render their existence possible.

The exhaustion of the world's supply of iron ores has been repeatedly predicted and one essential difference between the lode in which ores of iron and those of most other metals occur seems at first to give some plausibility to such forecasts. The lodes of gold, copper and tin met with at or near the surface of the earth continue to great depths beneath it. Thus gold is being worked in Bendigo at a depth of 4,700 feet, copper in the Lake Superior region at over 5,000 feet and tin in Cornwall at 3,000 feet; no doubt such ores occur at even far greater depths. The best ores of iron, on the other hand, occur only at comparatively shallow depth: instead of being derived from solutions rising from the deep interior of the earth, they have been deposited on the surface or by water percolating downward from the surface; on this account, oxide ores in sufficient bulk and purity to be of present commercial importance are practically confined to the layer accessible to water containing oxygen; as that depth is limited, it appears most probable that the high-grade ores of iron will not continue downward to depths below the earth's surface in any way comparable with those reached by mines of copper, gold and tin.

It is true that the vast barysphere within the earth is composed chiefly or largely of oxide of iron; that mass, however, is separated from the surface by so thick a layer of rock that the material is quite beyond our reach; while the accessible igneous rocks rich in iron contain constitutents which render the material either useless as ore or so refractory, that if it had to be utilized the exhaustion of the world's coal supply would be seriously hastened.

Mr. Andrew Carnegie, in his Rectorial Address to the University of St. Andrews, in 1902, declared that the British iron ores were nearly exhausted, as the Cumberland supply was almost finished and the mines at Cleveland, except two, would last only for another twenty to twenty-five years. The British ironmaster has been warned repeatedly that the rich Spanish oxides which are used so largely in our blast furnaces will soon give place, as they are followed downward, to poor carbonates; and the American steel-magnate has been assured that the Lake Superior ore, on which the great iron and steel industry of the United States was founded, will be exhausted a few years hence. In answer to various jeremiads, numerous estimates have been made in recent years of the quantities of ore actually available. Much information was collected by the British consular authorities in a report edited by Sir Llewellyn Smith and published by the Board of Trade in 1905; but as these accounts came from men who had no special knowledge of the subject, they were irregular and incom-

* Reprinted from "Science Progress."

plete. Recognizing that the supplies of Scandinavian ore were becoming of increasing importance to the British iron industry, I invited Prof. Sjögren to read a paper at the Leicester meeting of the British Association upon the iron-ore reserves of Scandinavia. He kindly undertook this task and visited several of the more important areas to bring the information up to date; his valuable report was published in full by the Association.[1] Tornebohm had previously prepared an estimate of the iron-ore supplies throughout the world but the information available was so limited and unsatisfactory that his optimistic estimates were unconvincing. Prof. Sjögren, realizing the importance of more reliable and comprehensive data, proposed that the International Geological Congress should arrange for an authoritative estimate to be made by an international body of experts. The work was undertaken by the Congress and thanks to Prof. Sjögren and the secretary, Dr. Gunnar Andersson, a series of fifty-five reports has been collected, dealing with all the iron-producing countries of the world. These have been issued by the Geological Congress in connection with its recent session at Stockholm in two large volumes and a folio atlas.[2] They form the most comprehensive attempt yet made to estimate the total available resources of any mineral, as they include the whole world in their range; they deal with an industry conducted on so large a scale that the unit adopted is a million tons and of such antiquity that some of the contributors refer back to the time of Alexander the Great or the still earlier dawn of the iron age.

The reports on the different countries vary greatly according to the local condition of the industry. The most important reports deal with Great Britain, Scandinavia, Germany, France, the United States of America and Russia, the long report by Prof. Bogdanowitsch on this last country, owing to the comparative inaccessibility of some of the literature, being of special value. Some of the reports deal with countries which, like Belgium, once had important iron mines, the relics of these, M. Lespineux remarks, remaining as monuments of former folly. There are short notes on countries such as Holland, which contain only insignificant deposits of bog-iron ores far too small to be of commercial value; and there are general statements from some countries in which it has not yet been worth while to make an accurate survey of the ore, though the amount is known to be considerable.

The only continent of which the iron-ore supplies are adequately known is Europe. Prof. Sjögren considers it improbable that any new deposits of the first rank will be discovered in this continent but even the European estimates vary greatly in value and it is probable that they may be considerably increased. In the case of the British Isles, as the iron ores belong to private land-owners and not to the State, it is no one's business to estimate the available supplies. Prof. Louis's report on the British iron field is, therefore, of special interest, particularly as he takes a very pleasing view of the extent of our reserves. The British output of pig-iron is now over fifteen million tons per annum and there is still, on the whole, a slight annual increase in the amount produced. Prof. Louis concludes that the British Isles have in reserve 39,500 million tons, containing an average of from 30 to 35 per cent of iron. If all this ore could be used, it would supply all our blast furnaces for nearly 3,000 years. Prof. Louis, of course, recognizes that a very large proportion of the ores cannot be smelted profitably under any conditions that may be reasonably expected, though it may be added that he has formed a much more favorable view of the extent of the Wealden ores than I formed after some inquiry into their quantity in 1907.

Dr. Sjögren has divided the world into sections *A*—*D*, according to the extent to which available estimates can be trusted. In division *A*, which includes 13.3 per cent of the land of the world, the calculations are fairly trustworthy. In division *B*, including 10.3 per cent of the land, only very approximate estimates can be made. In division *C*, including 51.6 per cent of the land, no numerical estimates are possible. Division *D* includes the unknown countries and the Polar regions, covering 24.8 per cent of the land area. Hence even general estimates of the iron-ore supplies are possible for less than a quarter of the land of the world. Prof. Sjögren has recently proposed a formula which appears to yield the most probable approximation to the ore in the less-known countries. He takes the average iron-ore content per square mile of the lands in division *A* and multiplies this factor by the remaining land area; according to this method, the iron-ore supply in it is some 425,000 million tons. This cheering estimate may be exaggerated if Europe and the Eastern States of America, by some fortunate circumstance, have been endowed with more than the average share of iron; and as the iron-ores were only discovered after the settlement of those countries, it seems probable that the extent of the ore supplies is due to the thoroughness with which search has been made for them.

No doubt in some cases fuller knowledge may involve a reduction in the estimated quantities. Vague reports and traditions of mountains of iron-ore may prove to be exaggerated; stories of this sort in reference to China and India are discredited in this monograph. But there seems no reason to doubt that as countries now sparsely occupied become better known increased quantities of ore will be found in them.

As the monograph deals essentially with the quantity of ore, it does not often refer to the manner in which the ores have been formed. In some cases the genesis of an ore must be determined before the amount can be estimated. Iron ores can be classified according to their mode of origin into six main groups. The first, igneous ores due to magmatic[3] segregations in molten rocks, are represented by the titaniferous magnetites such as occur at Taberg in southern Sweden and at Routivaara in Lapland; but few ores unquestionably of igneous formation are at present of practical value. It is true that this origin is accepted by some leading authorities for the great masses of magnetite in Lapland; but this view is not yet established and Mr. Lundbohm, the manager of the Kiruna mines, both in his report in this monograph and in another submitted at the recent meeting of the Geological Congress, represents this question as still unsettled.

The second group includes ores formed as contact-deposits beside eruptive rocks; the present tendency is to transfer some ores, such as those of Gora Blagodat in the Urals, from the magmatic to this group. There is also a somewhat uncertain boundary between contact ores and those of the third group, the lodes and masses due to the replacement of other rock by ironstone. They are represented, for example, by the masses of rich kidney iron ore in the Carboniferous limestones of the north of England, which provide the only British supply of Bessemer ore. This group also includes the famous iron mines of southern and central Sweden.

The ores of sedimentary origin which form the fourth group include the most widely distributed ores, now of much economic importance. Among them are the Carboniferous and Mesozoic ironstones of the British Isles and of Spain, the Clinton ores of the United States and the vast beds of minette in France and Germany.

The fifth group comprises the banded ironstones and their associated ore bodies, which are ores of great importance in the United States and in all the existing fragments of the ancient continent of Gondwanaland. They occur in Brazil, South Africa, India and Australia. Hitherto it has only been in the Lake Superior region of North America that these ores have been of great importance; they have there furnished the main supply of material to the iron and steel industry of the United States. The iron has been concentrated into huge bodies of ore by water, which has dissolved the metal from the rocks above and deposited it where the descent of the solution has been stopped by some impermeable layer.

The last group includes the laterites which are so widely spread as superficial deposits in the tropics and sub-tropics. They extend occasionally farther into the temperate regions, occurring, for example, in workable quantities in the north of Ireland. Hitherto these ores have only been mined to supply local demands or for use as iron-bearing fluxes. Many primitive races still obtain their iron from laterite; the prehistoric smiths of the early iron age were probably mainly dependent on such ore and in the event of a serious rise in the price of iron ore laterite deposits would once again become of great industrial importance.

The estimates of the iron ore supplies throughout the world included in the various reports have been collected in tables compiled by Mr. Tegengren; the chief results are shown in the list in the next column.

The total reserves of ore are shown by the following list to be enormous and ample for all probable requirements. The estimates are the best hitherto made but they are inevitably indefinite. More precise estimates would hardly be worth the time and trouble it would cost to procure them. A final determination of the iron ore available is impracticable because there is no fixed test of what is ore, the availability of a material as ore varying with political and commercial changes. The percentage of iron in a material affords no absolute separation between iron-bearing rock and iron ore. Thus 60 per cent of iron in a material may be useless when associated with much titanium, while another containing only 20 per cent of iron may be a valuable ore. Commercial conditions also control the profitable working of ore and therefore affect the estimates hitherto made.

Material that in one place or time may be quite valueless may become a useful ore through some change in political or commercial conditions. For example, there are said to be large supplies of high-grade ore available in Honduras but it has not yet been worth any one's while to test these reports: no doubt, if Honduras were a great importing country the ore would be investigated at once, as it could then be exported owing to the cheapness of return freights. The working of British ores, on the other hand, is retarded because the ships that export our coal bring back ore at an abnormally low rate.

Country.	Actual Ore Supplies.	Equivalent in Metallic Iron.	Potential Ore Supplies.
	Million tons.	Million tons.	Million tons.
France	3,300	1,140	—
Luxemburg	270	90	—
Spain	711	349	considerable
Portugal	—	—	75
Italy	6	3.3	about 2
Switzerland	1.6	0.8	2
Austria	250.9	90.4	323.2
Hungary	33.1	13.1	78.9
Bosnia and Herzegovina	—	—	21.9
Servia	—	—	probably
Hungary	33.1	13.1	78.9
Servia	—	—	probably moderate
Bulgaria	—	—	1.4
Greece	100	45	probably moderate
Turkey	—	—	considerable
Russia	864.6	387.2	1056.3 +
Finland	—	—	about 45
Sweden	1,158	740	178
Norway	367	124	1,545
Great Britain	1,300	455	37,700
Holland	insignificant	insignificant	moderate
Belgium	62	25	—
Germany	3,607.7	1,270	enormous
Canada	considerable	considerable	probably enormous
Newfoundland	3,635	1,961	enormous
United States	4,257.8	2,304.6	75,105.3
Mexico	55	30	probably considerable
Central America	—	—	exist
West Indies	1,903	856.8	1,007
Columbia, Venezuela, Bolivia, Peru and Chile	4.2	2	considerable
British Guiana	—	—	exist
Dutch Colonies	—	—	exist
Brazil	—	—	5,710 +
Argentine	—	—	exist
Western Australia	—	—	20 +
South Australia	—	—	21.6
Queensland	—	—	13.7
New South Wales	48.9	26.8	5.1
Victoria	—	—	moderate
Tasmania	23	15	2
New Zealand	64	32	0.2 + considerable
Asiatic Russia	—	—	27 + considerable
British India	100	65	400 + considerable
China	100	60	probably enormous
Japan	55.6	28	moderate
Rest of Asia	4.8	2.5	—
Algeria and Tunis*	about 125	about 75	—

* The supplies in the rest of Africa are at present incalculable and are reported from the various States as considerable, moderate and enormous.

The conditions controlling the development of an iron ore are so complex that no simple rules can be stated and so some of the reports include ores containing as little as 20 per cent of iron; others restrict the limit to a minimum of 30 or 40 per cent or even 60 per cent. The lower-grade ores can be used if they form a good smelting mixture with richer ores or after the others are exhausted. Twenty years ago the ores used in the United States contained an average of 62½ per cent of iron; at the present time cargoes containing over 60 per cent are exceptional, the average being about 50 per cent; even cargoes of 40 per cent iron are used and in Alabama ores are mined and included in the reserves having on an average as little as 36 per cent of iron.

Though the data collected by Dr. Sjögren show that the fear of an iron famine is idle, the supply of ores containing 60 per cent of iron is acknowledged to be comparatively limited. The total supplies of such ore are estimated at 1,300 million tons of known ore and some 687 million tons of potential reserves. Of the known supplies, about 1,100 million tons or more than four-fifth of the total known amounts are in Sweden. In America, excluding ores too rich in titanium to be of present value, the reserves amount to only 58 million tons and are limited to Mexico and the West Indies; Australia reports 49 million tons in Westralia and Tasmania and an additional 34 million tons of potential reserves in South Australia and Queensland. In Asia there are 530 million tons, all belonging, however, only to the potential reserves.

At the present time about 60 million tons of pig-iron are produced every year; the production has on the whole more than doubled in every twenty years, so that if we were dependent on ores containing 60 per cent or more of iron, the known supplies would only last another fourteen years, though the potential supplies, which have been crudely estimated, including 250 million tons in India, would last another six or seven years. But when the lower-grade ores are included, the total actual reserves of iron are estimated at over 10,000 million tons, and the potential at 50,000 million tons, exclusive of enormous supplies which are still unmeasured and may amount even to ten times that great amount. The known supplies, at the present rate of production, would last two hundred years. Including the potential reserves, they would last over a thousand years; by lowering the grade of ore that iron-masters

[1] H. Sjögren, "The Iron-Ore of the Scandinavian Peninsula," Rep. Brit. Assoc. 1907, pp. 332-45.

[2] The Iron-Ore Resources of the World. An Inquiry made upon the Initiative of the Executive Committee of the Eleventh International Geological Congress, Stockholm, 1910. Vol. I., pp. lxxix + 552; Vol. II., pp. 553-1068, 22 pls., 142 figs.; Atlas, 43 maps.

[3] Magmatic ores are those formed by the concentration in a molten rock of a metallic constituent that is normally scattered through it into masses sufficiently large and rich to be worked as ore.

are willing to smelt, ample ore supplies would be available for further millenniums.

These estimates fully confirm the opinion expressed to the Geological Section of the British Association in 1907, when I remarked that—

"The geologist who knows the amount of iron in most basic rocks finds it difficult to realize the possibility of an iron famine; he can hardly picture to himself some future iron-master complaining of 'iron, iron everywhere and not a ton to smelt.' There are reserves of low-grade and refractory materials which the fastidious iron-master cannot now use, since competition restricts him to ores of exceptional richness and purity. When the latter fail, an unlimited quantity could be made available by concentration processes. The vast quantities of iron ores[4] suitable for present methods of smelting in Australia, Africa and India show that the practical question is that of supplies to existing iron-working localities and not of the universal failure of iron ores."

The future demands on the world's supplies of iron ore will be affected by industrial changes and on those of separate countries by their financial policies. Thus the introduction of reinforced concrete must materially diminish the demand on the iron ores. The adoption of a protectionist policy by a country may lead to the development of its own iron mines and perhaps the closing of those of some of its neighbors. Thus the imposition by the United Kingdom of a tariff on imported iron ores would no doubt lead to the working of British ores that now lie unutilized and might close some Mediterranean iron fields which can only mine iron ore for export, having neither fuel supplies nor water power.

Alarmists tell us that we are using an unfair share of minerals and that there will be none left for future generations. On the other hand, the well-known commercial principle, use an asset while you can, is applicable to many iron ores. For when South America, Asia, Africa and Australia smelt their own high-grade ores, iron produced from our poorer ores will not compete in their markets. Hence European ores which can be worked profitably at present may become valueless if not used before the newer countries establish iron industries of their own. If the present opportunity of working such ores be lost there may never be another.

The real danger to the future in regard to the iron-ore resources of the world is not the limited quantity of ore but the limited supply of coking coal necessary for its reduction. Even if the heat required for smelting iron be supplied electrically, one ton of coking coal is required for the reduction of two tons of iron ore. The supply of iron ore is unquestionably adequate; indeed, it is certain that there will be plenty remaining when there is no more coking coal left for its reduction.

[4] Presidential Address to Section C, Rep. Brit. Assoc. 1907, p. 501.

Document Photography—Its Use in the Courts

The Camera is Mightier Than the Eye

So VERY few people realize just how far scientific methods are employed in the detection and conviction of criminals that the following exposition by William J. Kinsley, examiner and photographer of questioned documents, will be found of interest. The original article appeared in the *American Annual of Photography* and is here reprinted with some editorial matter furnished by the author.

The first step in a contested questioned document case should be to photograph the entire document natural size. The next step to enlarge all of it, or any disputed or questioned parts. These natural size photographs should be made, if for no other purpose, merely as a permanent record, to forestall loss or theft.

A witness to a forged will in her anxiety to account for all of the unusual features of the document testified with emphasis and particularity about just how all of the blots on the instrument were made at the time of signing—including several blots which were made in the Surrogate's office some months after the document had been photographed! The witness did not know that the document had been photographed.

In another case where typewriting was in question and the disputed document was in French, it was found that the accent marks over the letters *were put on by pen and pencil*—thus showing that a typewriting

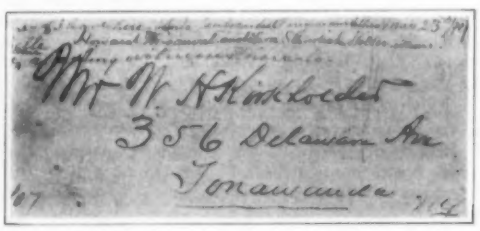


Fig. 11.—A Will Case. Shows close spacing between lines, words and letters. This spacing, together with curve of lines and space between "Belle" and "Howard" and the crossing of the "M" in "Mr." by the word "attesting" is conclusive that this part of will was written *after* the signature.

machine other than one made to write the French language was used.

When the document was again produced by the suspect at a second investigation, it was found that some of the most prominent and palpably-added accent marks had been covered by ink blots. The producer of the document had not learned that the document had been photographed!

It is a great saving of wear and tear on the original papers to have photographs of them.

For court use, photographs are very helpful. All parties interested, court, jury, lawyers and witness, have the same thing before them at the same time. The witness's explanation can be followed much more easily, and the peculiarities pointed out can be observed then and there—and not forgotten, as they would be oftentimes, when the jury retired for deliberation.

Photographs frequently disclose things unobserved by the naked eye. Patched and overwritten lines (Figs. 11, 9), erasures by chemicals or abrasion, differences in ink tints (Figs. 8, 13), differences in pens used, breaks in continuity of writing, underlying pencil lines, writing over folds in paper (Figs. 8, 14), tearing paper before or after writing, etc. Differences in printing, engraving, size and ruling of paper, etc., can be readily shown by photographs.

Chemical erasing stains being in most cases yellow, and the ordinary photographic plate being very sensitive to yellow, the faintest of stains, scarcely discernible to the naked eye, are reproduced much stronger on the negative—in some cases plain enough to read

Fig. 12.—Enlargement of questioned signature showing name "James Connelly" twice. Faint writing reproduced because of yellow stains left by erasing with chemicals.

what appears only as a faint yellow smudge in the original.

The "James Connelly" illustration (Fig. 12) shows a case of this kind. The defendant was indicted for giving as security for a bond, a house and lot he did not own. The bail bond book was a public record. After he was indicted the defendant said that the name signed to the book was not his signature. And when the prosecutor looked again, he found that the original signature had been erased by chemicals, the same name written over it—but in another handwriting, and a big blot put over part of the signature. Photographs were made and the faint yellow stain read "James Connelly." The expert for the prosecution testified at the trial that the faint writing was in the handwriting of the defendant. An expert for the defendant, who was in court, prepared to testify that the second or overwriting was not in the hand of the defendant, immediately after examining the photographs took his hat and left the court room.

Writing faded toward yellow will photograph quite black and thus makes it plainer in the photograph than in the original.

Color screens or ray filters are useful in many cases in catching any bit of color; and of course orthochromatic plates are often a necessity.

For enlargements over three diameters it is better to place the filter over the object, as it gives sharper definition.

By the use of contrast ray filters any color in the writing or document may be emphasized. Sometimes it is necessary to use a filter to correct the background in the paper—manila for example—or to exclude some extraneous thing—for example, a red blot on black writing, etc.

A transmitted light photograph will nearly always show differences in inks, thickness of strokes, quality

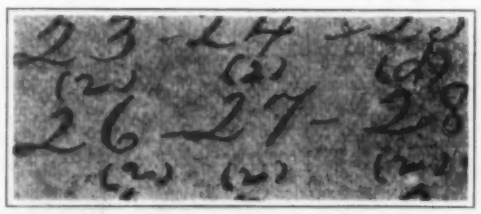


Fig. 13.—Transmitted light photograph of altered book account showing use of different inks and pens, and an erasure by abrasion.

of line, writing over fold in paper, retouching, patching and overwriting.—if these things are actually present. Two ink strokes that look practically alike to the unaided eye, when photographed by transmitted light, will show that two different inks were used (Figs. 8, 13).

Transmitted light photographs are also useful in showing watermarks, and wire mesh marks in paper; also the fiber of the paper. Sometimes erasures are shown up best by transmitted light (Figs. 6, 13).

Photographs are essential in many cases, because it is necessary to make a juxtaposition comparison. After photographing and printing the disputed and standard documents natural size, the parts necessary for comparison can be clipped from the prints and be arranged and pasted on thin cardboard or heavy paper. These clippings thus arranged can then be further enlarged up to any desired diameter. This makes a fair and effectual way of making the comparison and of showing the facts. If the writings are actually unlike, it will be easier to see their unlikeness when enlarged in this way. On the other hand, if the writings are alike, this fact will be demonstrated by such an enlarged comparison.

Comparisons cannot be properly made unless the writings to be compared are brought side by side; and for persons unaccustomed to making such comparisons (jurymen for example) it is absolutely necessary

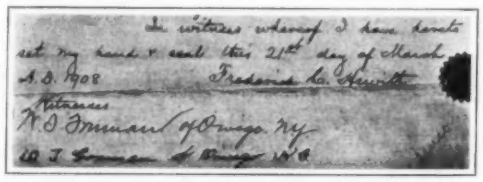


Fig. 14.—Signatures in Hewitt Will Case, showing differences in pens and inks; and showing writing over fold in paper.

to have the things to be compared arranged in this way.

Occasionally an enlarged photograph or photo-micrograph will bring out a point that may be the determining one in a case.

In a recent criminal court case an enlarged photograph was being criticised for the defense by an "expert" photographer, who admitted that he had never made such an enlargement. He found fault with a break in the line in the photograph of the disputed signature (which was a forgery by tracing), claiming that the enlarged photograph showed a condition which did not exist in the original. The trial judge looked at the original through a simple microscope and then handed the glass and original to the fault-finding witness, asked the witness to examine the original with the glass and see if the line was not broken just as shown in the enlargement. The witness admitted that it was and retired from the witness stand in considerable confusion. This witness afterward admitted that he did not know that writings could be enlarged to such a degree; that he did not know of any lenses as small as two-inch focus; or that the United States Bureau of Standards certified lenses.

There can be no reasonable objection to the use of photomicrographs. It would be as reasonable to object to the use of a microscope, or for that matter, to the use of eyeglasses by the jury or witnesses. Some few judges have ruled that only photographs of entire documents may be used. When an enlargement to twelve diameters (one hundred and forty-four times

the original area) of parts of a document is offered, arranged on prints 11 x 14 inches, it will be readily seen that if an entire document 8½ x 11 inches in size was enlarged to the same degree, a document eleven feet long would result; and the point aimed at—close comparison of significant characteristics—would be eleven feet farther away than in the natural size.

While bromide enlargements may occasionally be useful, in the great majority of cases direct enlargements are better since they give sharper definition. If an enlargement greater than the dimensions produced by the camera is wanted, the document may be photographed in parts and the parts cut and fitted accurately and then joined by binding tape.

Enlargements of typewriting are very useful to show not only design and defects, but also slant, spacing and alignment. Even differences in sizes of types in the different makes of machines can be seen best in photographic enlargements. Three to five diameters (Fig. 1) are sufficient for most purposes but occasionally a ten or twelve diameter (Fig. 3) enlargement will be found useful. Most people and judges and attorneys do not know that from typewriting can be identified: (1) Particular make of machine; (2) the individual machine that did the work; (3) the earliest date at which it was possible to have done this work; (4) and about what period the writing was done—all provided suitable standards can be had for comparison purposes.

THE CAMERA.

A suitable document camera should have five or six feet bellows extension. It should have an object board that can be readily removed; and have a rack and pionion permitting forward or back motions by the operator from the back of the camera by means of long pulls. The board should also have oscillating, horizontal and vertical movements. The camera proper travels on a bed, actuated by rack and pinion.

Levels should be placed on the object board standard and back of the camera, so that object and plate may be kept perfectly parallel. (Fig. 7.)

It aids in sharp focusing if a few cover glasses are fastened by means of Canada balsam, heated, on the ground glass side of the ground glass.

Cut-outs made of light wood (stained black), heavy paper or light cardboard, allowing two or more exposures on one plate, are useful. They are placed in front of the ground glass at back of camera.

A transmitted light holder, consisting of a base working on rack and pinion and moved by long arm from back of camera, by the operator the same as the object board, and two upright posts with clamps to hold the document, is necessary if transmitted light photographs are to be made.

If much traveling is to be done with the apparatus, the stand and camera should be of the "take-apart" kind for convenience and safety.

The camera bed should be marked with indicators, locating positions of object, lens and back of camera for different enlargements made by each lens used.

At least four lenses are needed for all kinds of document work: one or two inches, four or five inches, eight to ten inches, eighteen to twenty inches focus. Most lens makers have lenses especially adapted to document work, for enlarging, color corrected, etc. A greater number of lenses than four would be found useful, but are not absolutely necessary. The Bureau of Standards, Department of Commerce and Labor, tests and certifies to correctness of lenses. (Fig. 10.)

THE CAMERA STAND.

It is advisable to have a camera stand that will permit the camera being used at any angle between the usual horizontal and vertical, and for transmitted light it may be necessary to incline the stand to an angle of 45 degrees.

LIGHTING.

For daylight it is useful to have a white reflector to place on the side of the object away from the source of light. (Fig. 6.)

To show erasures by abrasion, indentation, roughness of paper; or to light seal impressions, a side light admitted through a narrow opening (one-eighth to one-quarter inch) in a paper shade is a successful method.

Artificial lighting permits of making photographs at night and the darkest of days and getting uniform exposures.

Inclosed arc lamps on stand; tungsten incandescent lamps; Cooper Hewitt mercury lamps and other kinds work well. It has been found by some operators that owing to low actinic value in light produced, exposures made with tungsten lamps require much longer (several times) time than the volume of light would indicate.

Arc light stands should be adjustable.

The tungsten light shown in the illustration is a 250 watt and is in a special hanging Frink hood-reflector concentrating the light on the object. (Fig. 6.)

The large hood on four legs shown in group is made of press-board lined on the inside with white cardboard. (Fig. 6.)

Mirrors are sometimes necessary to catch direct sunlight rays and throw them on the object for enlargement.

A beam divider for ground glass measuring; accurate rule (steel preferred) for enlarging to scale; a strong focusing glass (eight to twelve diameters); and accurate paper scale graduated to sixty-fourths of an inch and two inches long (Fig. 4) to place beside object so as to have a permanent record of enlargement; a focusing scale of tints, lines, dots, etc., to enable the operator to secure the greatest definition are all really necessary accessories.

Slow plates are best for use for document work. But it is necessary to keep in mind that photo-engraver's or process plates giving strong contrast are not the right kind. What is wanted is the greatest detail and gradation in line construction.

For objects in which there is color, of course an ortho-chromatic plate (and a ray filter) should be used.

Glossy paper, "hard" or "soft," as necessary to best reproduce the object, is what will show greatest detail. A "hard" paper will be found proper in most cases. All prints show up best for document work when ferrotyped. Developing paper gives satisfactory results, but P. O. P. may be used if desired.

The best way to mount prints is to back them with backing paper of the same make. This keeps them smooth and flat, agreeable to the touch, not heavy, and permits of easy and convenient binding.

If all prints are made a uniform size irrespective of the size of negatives, with tabbed ends, hinged with cloth, perforated, they can be bound in loose-leaf binders of uniform size, and the prints fastened in place with paper fasteners and washers.

Very great enlargements covering much space may be made in sections, hinged with binding tape and folded at hinges.

It will be found helpful to card ndex all cases giving numbers and dates of negatives, etc. Envelopes should be used for all negatives and the envelope should bear a serial number, date, etc., just as much of the exposure record as may be thought necessary. The negatives should be filed according to size; and then in numerical order. By this system negatives will be carefully preserved and always accessible.

The original papers should be kept unfolded if possible, and of course should be handled as little as possible, and then carefully. If the questioned document is put between plates of glass or celluloid, it can be readily examined and will be protected.

Checks, notes or small papers may be covered with glass, which can be fastened to object board by means of push pins. Or the papers may be held in place by metal strips fastened with push pins or by finger-pins—if the glass is found objectionable because of reflections.

Light pencil figures giving dates or exhibit numbers are often useful in photographs. They may be written on the documents themselves or on narrow slips of paper to be placed alongside the writings when making the exposure.

If a record is kept of each exposure (Fig. 4) the lens certified by the United States Bureau of Standards (Fig. 10) and the negative produced in court if desired and the process described, there can be no reasonable objection made to the use of such photographs.

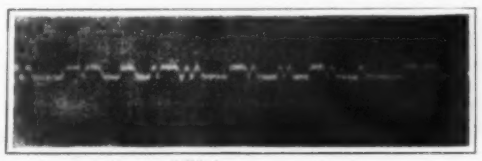
Photographs can be made improperly, but with modern certified lenses in a scientifically constructed camera and the original document in court for comparison, there need be no fear that any injustice will be worked by photographs properly checked up.

Photographic Receiver for Wireless Telegraph Signals

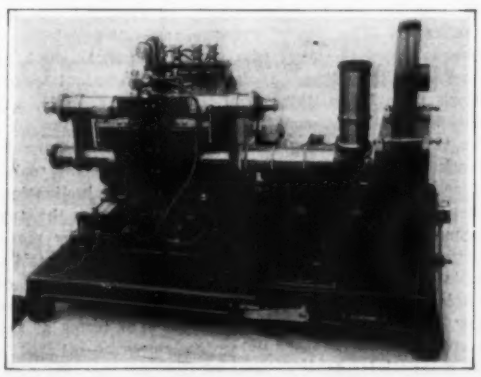
By the English Correspondent of the Scientific American Supplement

IN the earliest days of trans-Atlantic wireless telegraphic communication, Mr. Marconi employed a special type of coherer which he had evolved. With this instrument some remarkable results were obtained. But as the system developed it was ascertained that the possibilities of the coherer were limited in connection with long distance work. Operation, however, served to offer experience concerning the causes for irregularity in the strength of the signals, and particularly of the effect of sunlight. It was observed that the short waves employed on the latter days were more liable to variation than longer waves, and arrangements from time to time were made for increasing the length of wave employed. Simultaneously with the alteration in wave length, however, the number of trains of waves per second was increased, resulting in the production of a wireless signal unsuited to the coherer, and necessitating the development of another type of instrument in the form of the magnetic detector. For some time this instrument fulfilled all requirements and was successful on account of its extraordinary simplicity and robustness. But as progress continued to be made, and as the necessity for handling greater volumes of work with higher speed and louder signals began to be felt, another device was demanded which was furnished in the shape of the valve receiver. At the present time this is the standard instrument employed on trans-Atlantic wireless telegraphic communication.

Still it was realized that an aerial receiver dependent for its rapidity of working upon the ability of the operator to receive by sound was not the final solution, and continued efforts were directed to the production of a recording instrument so that the speed of transmission might be augmented. Various tests have been made, and where signals have been very strong, successful results have been achieved with an ordinary Wheatstone transmitter and a relay. This system, however, has severe limitations, for it has been found that where great distances have to be spanned and where signals are of normal strength such crude devices as a commercial telegraph relay cannot be applied for the apparatus is far from being sufficiently sensitive.



Record Made by the New Receiver.



Wireless Telegraph Receiver That Makes a Photographic Record.

Recent experiments in another branch of research and electrical experiment have developed a device of extreme sensitiveness. For physiological investigations the Einthoven galvanometer was elaborated for the study of natural electric currents. Mr. Marconi, impressed with the sensitiveness of this appliance, at once attempted to adapt it to his invention. The application of an instrument so easily affected, although a natural step in the solution of his problem, however, was not final in itself. The Einthoven galvanometer had been evolved for purpose totally different from that which he desired, and was not capable of responding to high speed signals. Still he decided that it constituted an ideal base on which further progress could be effected.

His experiments have proved successful, for by altering the original design of the instrument to meet his requirements, and by combining it with the latest type of valve receiver he has succeeded in perfecting an apparatus capable of responding to all speeds of transmission available at the present moment. Moreover by introducing a photographic attachment he is able to secure an indelible photographic record of the signals received similar to those produced in the cable system as may be seen from the accompanying illustration, which we are permitted to publish through the courtesy of Mr. Marconi. Development in the future is dependent on providing the means and power for high speed transmission as much as on improvements in the design of the recording instrument now employed.

The Rolling of Ships and the Possibility of Capsizing*

The Dynamics of the Problem

By Prof. J. H. Biles, LL.D., D.Sc., M.Inst.C.E.

IT has occurred during recent years that accidents have happened to ships and they have mysteriously disappeared. The complete disappearance without leaving any trace has led to the assumption that the vessel has capsized. The circumstances of such cases obviously preclude the existence of any direct evidence. The only subjects of investigation can be (1) the condition of the ship prior to the accident, and (2) the probability that such a condition could be one which in any known possible circumstances could lead to disaster. The first is determinable by evidence in any particular case; the second involves a consideration of the whole question of the behavior of ships at sea. What is the effect upon any given ship of a known series of waves? What waves is a ship likely to meet? This subject has occupied the attention of scientific engineers, and it may be said to have been considered a solved problem. We have thought that if a ship has a certain metacentric height and a certain range of positive stability, she is quite safe from the action of a series of waves of any kind which we know to exist. If, however, a known ship (and perhaps more than one) has these safety-insuring qualities, and mysteriously disappears, it may be desirable to review the grounds of our belief to see whether any known possible combination of circumstances may cause disaster. Let us, then, first briefly review the grounds of our belief. Fifty years ago Mr. Wm. Froude showed that the large angles occasionally reached in rolling are not due to a single wave-impulse, but are the cumulative effect of the operation of successive waves. The period T of a small oscillation of a ship in water free from wave disturbance and resistance is

$$\pi\sqrt{\frac{k}{gh}}$$

where k is the radius of gyration, and h is the metacentric height, i. e., the height of the metacenter above the center of gravity. The period T of a wave is

$$\sqrt{\frac{2\pi l}{g}}$$

where l is the length of the wave, and g is the acceleration due to gravity. The line of action of the resultant of the supporting pressures acting on a ship in undisturbed water is the vertical through the center of gravity of the volume of the water displaced by the ship. In wave-water it is in the normal to the effective wave-slope (which is approximately the wave-surface). The oscillation of this normal as the waves pass causes a varying couple tending to incline the vessel. If the vessel is very quickly inclined by this couple, she will place herself in or near the normal, and the inclining couple will be of zero value. If, however, her movements are very slow, the normal may make one or more oscillations before any appreciable effect is produced on the vessel. The tendency to incline in one direction caused by the normal acting on one side of the vertical is checked by the rapid oscillation of the normal to the other side of the vertical. It is, therefore, evident that the relation between the period of the ship and that of the wave normal is a dominating feature in the resulting movement of the ship. Mr. W. Froude's mathematical solution of this relation is the basis of our belief that we understand the behavior of a ship in the *uniform* system of waves when the vessel is placed broadside on to the waves. To obtain this solution, he assumed that within the limits considered the moment of stability varied as the angle of inclination. In the curve of righting-levers of a ship, usually known as a curve of stability, this condition holds generally for angles up to about 10 degrees. The curve usually reaches a maximum value at about 30 degrees to 40 degrees, and vanishes at 60 degrees to 80 degrees, so that for large angles of roll the assumption does not hold. On this assumption, however, he showed that the motion of a ship among such a system of waves is the same as for still water plus a motion composed of two sine terms. The amplitude of this latter motion depends upon the maximum slope of the waves and the ratio T/T_1 (the period of the ship in undisturbed water to the period of the wave). If the ship starts from rest in the upright, θ is the maximum angle of inclination of the ship, and θ_1 the maximum wave-slope; then

$$\theta = \theta_1 \frac{1}{1 - T^2/T_1^2}$$

He considered several solutions of the equation of motion: (1) $T = T_1$; this is synchronism, and the angle of inclination gradually increases. Each wave impulse adds something to the ship's inclination, and without any resistance to rolling the vessel would capsize. (2) $\frac{T}{T_1} = 0$. This is the case of the ship's period being very small compared with that of the wave. θ will then be positive and equal to θ_1. In other words, the ship will place herself normally to the wave-slope. The maximum amplitude will only be the maximum wave-slope. (2) $\frac{T}{T_1} < 1$. In this case the wave-period is greater than that of the ship, and θ is always positive and greater than θ_1. The vessel always inclines away from the wave-slope. If

$$\frac{T}{T_1} = \tfrac{1}{2},\ \theta = 1\tfrac{1}{3}\,\theta_1.$$

If —

$$\frac{T}{T_1} = \tfrac{1}{4},\ \theta = \tfrac{4}{3}\,\theta_1.$$

If —

$$\frac{T}{T_1} = \tfrac{3}{4},\ \theta = 1\tfrac{5}{7}\,\theta_1.$$

The nearer $\frac{T}{T_1}$ is to unity the larger is the maximum amplitude. (4) $\frac{T}{T_1} < 1$. In this case the wave-period is less than that of the ship, and θ is always negative. The vessel inclines toward the wave-slope. If—

$$\frac{T}{T_1} = 1.1, \text{ then } \theta = -4.76\,\theta_1;$$

$$\frac{T}{T_1} = 1.26, \text{ then } \theta = \theta_1;$$

$$\frac{T}{T_1} = 2.0, \text{ then } \theta = \tfrac{1}{3}\,\theta_1;$$

$$\frac{T}{T_1} = 2.235, \text{ then } \theta = \tfrac{1}{4}\,\theta_1.$$

This shows the advantage of having T greater than T_1. He showed that the ship goes through a cycle of changes, and considered the effect of variations of $\frac{T}{T_1}$ upon these cycles. He showed that $\frac{T}{T_1} = \frac{5}{4}$ is better than $\frac{T}{T_1} = \frac{4}{5}$, so that it is better to lengthen T rather than to shorten it. Similar results for $\frac{T}{T_1} = 2$ and $\frac{1}{2}$ respectively gave better results by lengthening than shortening T. In each of the cases $\frac{T}{T_1} = \frac{5}{6}$ and $\frac{T}{T_1} = \frac{6}{5}$ the results showed baulked oscillations in which, while the vessel swings toward the vertical, she does not reach it, but swings back again. The lengthened value of T here also gave better results than for shortening it. The results given above are greater than would be obtained in practice, because resistance has been neglected. Later he determined the effect of resistance upon rolling in still water free from waves. He determined the law of resistance, and found it to vary partly as the angular velocity and partly as the square of it. He rolled a ship, and after she was allowed to roll free from disturbance he measured the angle of inclination at the end of each roll. These showed the rate of extinction of the rolling due to the resistance. The loss of extreme angle of roll between one roll and the next represented the work done by the ship in rolling. It is possible to calculate the work done in inclining the vessel to any angle, and the difference between the amount of work thus done in two different angles represents the difference in work necessary, and therefore work done, in resistance to bring the ship to these angles of inclination. Hence the work done by resistance between the two consecutive rolls can be actually measured by measuring the extreme angle of inclination in successive rolls. Having determined the resistance in terms of angles of roll and time, it was easy to determine the law which represented the resistance in terms of the angular velocity. In applying this to waves, all that is necessary is to take account of the fact that the position of equilibrium about which the ship oscillates is the normal to the effective wave-slope. This normal has a definite oscillation about a fixed vertical. It is, therefore, possible to determine the angle of inclination in terms of time. As these angles of roll may be considerable, the assumption upon which the general solutions for unresisted rolling, already given, were based, will not hold. The actual moments of stability depend upon the form of the ship and the position of its center of gravity, and, as these vary in different ships, it is only possible to obtain the relation between inclination and time by a special investigation in each case. A solution by a method of graphic integration was devised by Mr. W. Froude, and has been applied to a very small number of cases. The information necessary to obtain a solution in any one case is as follows: (1) A curve of righting-levers in terms of angle of inclination. This is called a curve of statical stability. (2) The form and period of the wave on which the ship is supposed to be placed broadside on. (3) The constants which determine the actual value of the resistance moment in terms of the angular velocity. These can be obtained by rolling the ship in still water, and observing the rate of extinction of rolling when that extinction is due to resistance only. The form of the curve of extinction can be obtained by rolling a model of the ship; but the actual ordinates of the curve for an actual ship can only be obtained by experiment on the ship herself, or by inference from a similar ship of approximately the same size, form, and arrangements. A consideration of these three necessities for the solution of one particular case shows that a considerable amount of work is necessary for determining the angle of inclination in terms of time. Even this solution can only be made for one assumed maximum angle of inclination as a starting condition. For instance, in any case where a ship is assumed to start with a maximum inclination of 20 degrees, it is only possible to obtain one solution of angles of inclination in terms of time. If we take another maximum angle of inclination, another complete solution is necessary. The work of each solution is considerable. For ships which vary much in draught and condition of loading it is evident that for each ship the work of complete investigation for all the conditions of loading of different waves and different angles of maximum inclination is very great. For this reason the investigation of rolling by the Froude graphic method has only been made for a very small number of cases, and our knowledge of the actual angles of inclination of ships obtained by this method is very small. The curve of statical stability is worked out for many ships in a few conditions of draught and position of center of gravity. These curves are of little practical value, because they only serve as comparisons between ships. It is assumed that if a ship has a fair range of statical stability, i. e., that the angle of vanishing statical stability is not less than, say, 60 degrees, and the maximum righting-lever is not unlike some previous ship which "has been to sea and come home again" safely, this ship will be safe. This assumption is based on the belief that only what has happened to previous ships will happen to the one in question, that is, that the contingencies of waves will be the same in all cases. But when we find that occasionally ships are missing, we are compelled to ask ourselves the question, Is it possible that some occasional contingencies of sea or ship, or both, may exist which will produce a dangerous, and perhaps fatal, roll? Mr. W. Froude's investigations were made for a uniform system of waves. He showed that in unresisted rolling a ship initially at rest and in the upright position is acted upon by a uniform series of waves such that $T/T_1 = p/q$, where p and q are the smallest whole numbers which express this ratio, then the rolling of the ship will be in cycles, the maximum inclination in each roll gradually increasing, and again gradually diminishing, and so on. The period of occurrence of the maximum of maxima will be $2\,q\,T$. The number of times the ship passes through the upright in each complete cycle is $2\,p$ or $2\,q$, whichever is the smaller. The ship is upright at the middle of the cycle, and on either side of this middle there is an equal maximum, which is approximately $\theta_1 \frac{q}{q-p}$, and never exceeds this value (where θ_1 is maximum wave-slope). If T is much larger than T_1, and therefore p is much larger than q, then the value of $\theta_1 \frac{q}{q-p}$ approaches $-\theta_1 \frac{q}{p}$ and is less than the wave-slope. If T is much

* Address before the Engineering Section of the British Association.

smaller than T_1, then the value of $\theta_1 \frac{q}{q-p}$ approaches θ_1. If T is nearly equal to T_1, then $\theta_1 \frac{q}{q-p}$ approaches a high value. From this it is seen that our investigations in unresisted rolling may be over a very wide field, but would produce no definite result in the matter of finding cases of large angles of roll in practice. We can only obtain valuable results when resistance is included. Mr. R. E. Froude in 1896 was led to deal with the subject of non-uniform rolling of ships in an assumed uniform system of waves which did not synchronize with the ship, such as is dealt with above for unresisted rolling, and he dealt with the effect of resistance in such a case. He pointed out that there is a particular phase-relation between the ship and the wave which will produce uniform rolling, just as there is in the case of a synchronous system of waves. If at any stage, for any reason, the rolling is of the cyclic character considered in non-resisted rolling, then the resistance must gradually introduce uniformity, because the rolling is made up of two sets of oscillations: (1) That due to the rolling relatively to the water surface, such as would occur in undisturbed water; (2) that due to the oscillation of the water surface itself, caused by the passage of the wave. We have already seen that the resisted oscillation in undisturbed water gradually decreases when the vessel is left free to oscillate, but takes place in practically uniform time T. The oscillation of the water surface is forced on the ship, and causes a simple harmonic oscillation of the ship in time T_1 in algebraic addition to that due to the free resisted oscillation. When the maximum angle of a roll due to the free oscillation coincides with the maximum angle due to the forced oscillation of the wave, we shall have a maximum extreme inclination, which is the sum of that due to the free and the forced. When they are in opposition, we shall have a minimum extreme oscillation, which is the difference of these two. At stages between coincidence and opposition we shall have extreme angles varying between maximum and minimum. As time goes on, the extreme angle due to the free oscillation gradually decreases under resistance, and the sum and the differences referred to above approximate to each other, and the rolling becomes that due to the wave alone. We have seen that in the case of unresisted rolling, where the wave and the ship synchronize, there is an addition to the angle of inclination for each passage of the wave, and were it not for resistance these accumulated increases would cause the vessel to upset. But in the case of resisted rolling, each increase of extreme angle of roll causes an increase in the work done upon the resistance of the ship, and when the increase in work done in increasing the angle of heel by each passage of the wave equals the work done in increasing the resistance incurred in swinging through this greater angle, then we shall have a balance of condition and a uniform angle of rolls. The angle at which this balance takes place depends on the period and maximum slope of the wave and the coefficient of resistance between the ship and the water. For instance, with a maximum wave-slope of 3 degrees, and with a ratio of ship to wave-period of 1.1, the value of the angle of ultimate uniform rolling in the case of H.M.S. "Revenge" was found to be 13.9 degrees without bilge-keels and 10.8 degrees with them. In the case of synchronism of the ship and the wave, the rolling is uniform always, and reaches a maximum of 41.1 degrees without and 14.85 degrees with bilge-keels. The nearer the wave and ship are to synchronism, the larger is maximum inclination reached before uniform rolling sets in, and during uniform rolling. Resistance is of much more importance in the case of synchronism. If the ratio of ship to wave-period be 1.3, the maximum angle before uniform rolling is reached is 8.25 degrees without and 6.6 degrees with bilge-keels, while that due to uniform rolling is 4.35 degrees without and 4.24 degrees with. We see, therefore, the important part that the near approach to synchronism plays in creating large angles of roll, and the value of bilge-keels in reducing the rolling in conditions approaching synchronism. When on waves of smaller period, when small angles of roll may be expected, the bilge-keels give but small advantage. The assumption in these cases is that the vessel starts from rest in the upright in the mid-height of the wave, and that the rolling is caused by the assumed uniform swell. The vessel will go through the cyclic change already described, and will reach a maximum inclination of not more than double that which she reaches when uniform rolling has set in. A later investigator, Col. Russo, of the Italian navy, found by experiment that by varying the assumption as to starting condition of the ship, by letting the wave-action begin to operate first when the vessel is upright and at rest on the crest of the wave, the maximum angle before uniform rolling sets in can be more than four times that due to uniform rolling if the time of the ship is greater than that of the swell. There is an infinite number of solutions of rolling among waves, for the reason that there is an infinite number of initial circumstances; but whatever these may be, the rolling in a uniform swell will always soon degenerate into a series of uniform forced oscillations in the wave-period. From this discovery of Col. Russo's we see that the region of investigation of possible causes of upsetting is removed from that of uniform rolling even in a non-synchronous sea. The following table shows for the "Revenge," with bilge keels, the variation in maximum angle of inclination before and during uniform rolling in terms of the period and length of the swell:

Period of swell in seconds—	8	10	12	13.3	15	17	19
Length of swell in feet—	328	512	738	910	1,153	1,481	1,850
Maximum angle in degrees before uniform rolling—	6.3	8.0	14.7	21.4	17.1	13.0	11.0
Maximum angle in degrees during uniform rolling—	2.5	4.2	12.6	21.4	15.4	11.0	8.7

The period of free rolling of the "Revenge" through small angles for a double roll was about 16 seconds. The foregoing shows that the maximum rolling (which occurs at synchronism) took place at a period of swell of 13.3 seconds. The period of roll was less at large than small oscillations. The above figures are for waves varying from one thirty-seventh to one fifty-fourth of their length in height. The length of wave which corresponds to maximum inclination is 910 feet and height is about one-fiftieth. The maximum wave-slope for such waves is 3.6 degrees. We are in the habit of dealing with waves of one-twentieth of their length in height for strength calculations. Observers have recorded waves in the open ocean of 600 feet to 800 feet in length and of 30 feet to 45 feet in height; so that we know that the slope of the waves assumed by Col. Russo is much less than may be encountered at sea. A wave whose length is twenty times its height has a maximum slope of 9 degrees. Records of waves having a ratio of height to length of as great as one-thirteenth have been published. The maximum slope of wave corresponding to these proportions is 14 degrees. If it is admissible to take much larger angles of wave-slope, we may expect to get much larger angles of maximum inclination both before uniform rolling sets in and when it does. In a case given by Mr. Froude, in which the maximum inclination in the "Revenge" before uniform rolling was 12.0 degrees he showed by calculation that the corresponding maximum wave-slope must have been 5.09 degrees. For 20 degrees maximum inclination the wave-slope was 10.3 degrees. Both these cases were for periods of ship and wave of 16 and 13 seconds, respectively. For similar periods of 16 and 14.6 seconds the wave-slope to produce 20 degrees maximum before uniform rolling is only 7 degrees. These figures give some idea of the effect of the wave-slope on the maximum inclination. It is to be remembered that these are the maximum angles obtained by Mr. Froude; but if we take Col. Russo's maximum angles, which in some cases are double those obtained by Mr. Froude, it is easy to see that large wave-slopes may produce very large angles of roll. Summarizing, we see that: (1) With wave-slopes of 3.6 degrees the angles of maximum roll obtained by them in the "Revenge" with bilge-keels may be taken at 22 degrees. (2) This roll takes place when synchronism exists between the wave and the ship, when the wave is 910 feet long and 18½ feet high, and has a wave-slope of 3.6 degrees. (3) Waves exist which are of this length, but which may have a height of 50 feet, and possibly more, and a wave-slope of 10 degrees. (4) In such steeper waves we should expect to get much larger angles of roll. (5) Each ship has peculiarities of rolling due to its form as well as to its lading and bilge keels, etc. (6) These peculiarities and the effect they have upon rolling, and the effect different waves will have upon the rolling of the ship, can best be studied experimentally.

Enough has been said to show what a field of investigation is open to the experimenter. The little that has been done and published by Col. Russo is only for three battleships of about the same size. From the preceding it will be seen that it is possible to determine experimentally the kind of rolling which will take place in a ship which is snug and seaworthy. But it is also possible to study the effect of loose water in a ship under the same set of conditions as to waves, lading, and form of ship. This part of the subject has received experimental treatment only in a limited number of full-sized ships. The subject has been treated as one in which it is probable that the kind of waves met with at sea will be uniform in size and period. That this is not so is a fact with which we are all more or less familiar. The effect of a uniform system of waves is to rapidly induce a condition of uniform rolling. But any deviation from uniformity of sea immediately introduces non-uniformity of rolling, and generally greater extreme angles of roll. Any experimental study of the action of waves upon a ship must include a variation in the character of the waves. The field of investigation is thereby widened. But the work is of a kind which can be done by many people, and can be done fairly rapidly, so that there seems to be no insuperable objection to doing it. —*The English Mechanic.*

A Midnight Visit to the Zoological Gardens Sleepy and Lively Animals.

AFTER the closing time, about sunset, the animals in the Zoological Gardens for the most part are left to themselves. The superintendent and assistant superintendent and some of the younger keepers live on the premises, and are ready for any unusual event, while two night watchmen patrol the grounds, stoke the furnaces of the heating plants where necessary, and are on the lookout for intruders, fire, or accidents. The small tropical birds in the new bird house will not feed in the dark, and in the long winter nights the watchmen turn up the lights for a few minutes, at least once, between the departure and the arrival of the keepers. In the case of practically all the other animals with indoor and outdoor compartments it has been the custom to feed them in their inner dens before the keepers leave and shut them up until the morning. When the hot weather came on this summer, however, it was decided to give the animals, wherever possible, free access to their outer cages during the night. The doors of the inner dens have been left open, and in some cases new apertures have been made high up in the walls so as to avoid draughts along the floors.

On a recent visit to the Gardens on a warm evening about midnight the badgers in the north garden were observed to be lively and active, but the civets were all invisible. Most of the owls were asleep on their perches in the open air, and took no notice of passers-by, but the barn owls were on the alert, and even with the most stealthy care in approaching them they had retreated to their inner compartment with a ghostly shuffle before we could see them. The parrots in the large aviary were all asleep undisturbed by footsteps, but the owl-parrot, which keeps in its box all day, and the keas further along the canal bank were running on the ground. In the lemur house the striped Tasmanian wolves came running out to see what was happening, and the cat-bears were out on their branches, but the lemurs and coatis were either indoors or bunched together in tangled groups and all fast asleep. The zebras and donkeys were moving about, but the giraffes, rhinos, and chamois were all indoors and every kangaroo was asleep and not to be aroused.

In the south garden the large mandrill near the main gate was fast asleep indoors, and took no notice of his late visitors, but the apes and baboons in the old crows' cages were on the alert. The Polar bears were asleep in the open, Barbara with her head on Sam's chest, but woke up at once and came round at a great pace to where we were standing. The lion cubs, leopards, and cheetahs in the King's Collection were at the wire partitions on the alert, and were tame and very friendly, submitting their noses to be rubbed and their ears pulled, but one of the leopards seemed to be trying to stalk us, crouching on the ground and making sudden leaps against the bars. There was no doubt about the intentions of the fine pair of Siberian tigers; by day they display an aloof indifference to visitors, but at night they followed round and round their enclosure, sometimes making sudden rushes, sometimes crouching and springing. The other tigers and the jaguars and lions in the outdoor cages were frankly sleepy, and as they lay against the bars allowed themselves to be patted without making any demonstration.

The seals and sea-lions in the great pond were dashing about as if they expected an extra meal. The ostrich and the rheas were invisible, but the emus were marching up and down. The Cape hunting-dogs and the jackals in the King's Collection were lying motionless on the cinders, but as we passed they sneaked silently off, like dim shadows. The dingoes, foxes, and wolves heard us as we came along; first a little fox began to scream, and then one after another joined the chorus, until the whole set howled and wailed, sending a rising and falling volume of sound far across the Park.

The deer, antelopes, cattle, swine, and most of the smaller rodents were almost all invisible, either asleep in their inner compartments or crouching in the darkest shadows, and the vast majority of the birds took no notice of our passing. The eagles and vultures and all the game-birds were certainly asleep, but here and there a waterfowl piped or croaked as we came along, while some of the ducks and the black-necked swans were moving on the water.—*The London Weekly Times.*

The Manufacture of Permanent Magnets*

An Industry of Comparatively Recent Growth

By F. B. Hays

PERMANENT magnets are used on magnetos, tools, slot-machines, toys, voltmeters, ammeters, speedometers, telephones, wattmeters, ignition devices, recording instruments, compasses, controlling devices, physical instruments, and switches. The magnets used on these devices are of various shapes and sizes, the illustration, Fig. 1, representing the most common forms in use at the present time.

The extensive use of permanent magnets, together with scientific methods of manufacturing them, has come about only in recent years. Ten years ago the production of permanent magnets was a branch of manufacturing of very little consequence, while to-day

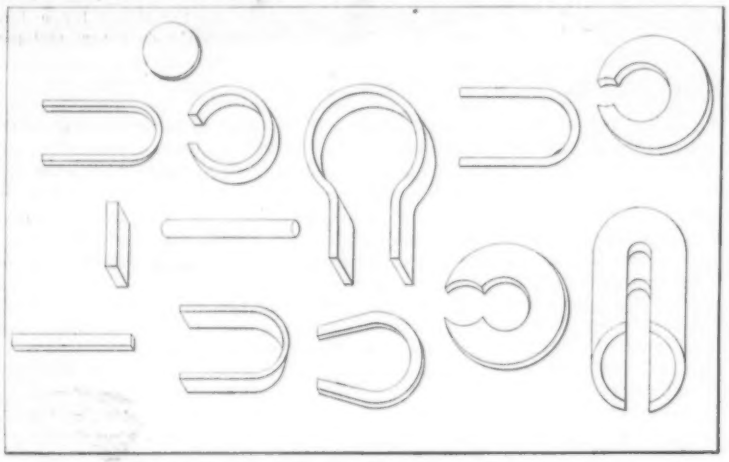


Fig. 1.—A Collection of Various Types and Shapes of Permanent Magnets.

it is one of the important phases of the steel-working industry. Every plant making permanent magnets has its own process of manufacture, but the underlying and fundamental principles for the production of successful magnets are the same in all. A summary of these methods is given in this article.

STEEL USED FOR MAKING THE MAGNETS.

Permanent magnets are made from alloy steels. The composition of these steels is governed to a large extent by the various purposes for which the magnets are to be used. For instance, telephone magnets are made from 50- to 60-point carbon steel containing a high manganese content. Where a stronger magnet is required, as for magnetos, a 50- to 60-point carbon steel with a 3 to 7 per cent tungsten content is used.

Magnet steel is hard and tough before hardening, and its physical properties closely resemble those of low carbon tool steel. In several plants the scrap from the magnet department is used for lathe and shaper tools in the machine shop. After hardening (chilling) the steel becomes as hard and nearly as brittle as glass. Magnet steel is rolled into bars and sheets of any desired size. Bar magnets such as are used on wattmeters and most magnetos are made from bars, while plate magnets such as those in telephone receivers and on some types of magnetos are made from sheets. The principal requisites of a good magnet steel are: uniformity of composition, freedom from blow-holes and seams, high magnetic qualities, retentivity, and freedom from cracks and blisters after treating.

* Reprinted by courtesy of *Machinery*.

SYNOPSIS OF THE METHODS OF MAKING MAGNETS.

The process of making permanent bar magnets may be divided into five distinctive steps as follows: (1) Testing the steel; (2) cutting the bars to proper lengths; (3) heating and forging; (4) heating and hardening; (5) grinding and magnetizing. For plate magnets, the process is shorter: (1) Testing the steel; (2) punching the plates from the sheet metal; (3) grinding and magnetizing.

TESTING THE STEEL.

Magnet steel is usually tested both at the steel mill and at the plant where it is used, to determine the proper "heats," and the magnetic qualities of the steel. Several methods are employed to determine this information, the most efficient of which is the following: Test bars and plates of magnet steel, as well as magnet forgings, which have been treated at different heats are tested for strength, permeability, and retentivity by means of a direct-reading permeameter. The results of these tests show the best temperatures for treating the steel, and also furnish complete data regarding its magnetic qualities. This method is used in the large steel mills and also in most modern magnet manufacturing shops. A direct-reading permeameter which is used for testing the magnet steel bars is shown in Fig. 2. This instrument is made by the Esterline Co., Lafayette, Ind.

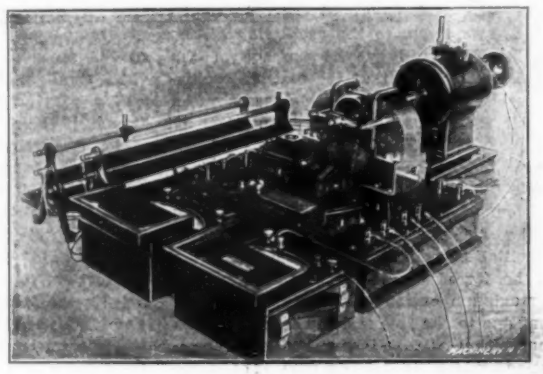


Fig. 2.—Esterline Permeameter Used for Testing Magnet Steel.

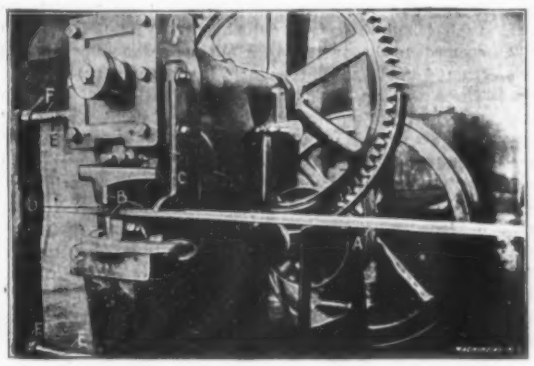


Fig. 3.—Shearing Magnet Bars to the Required Lengths.

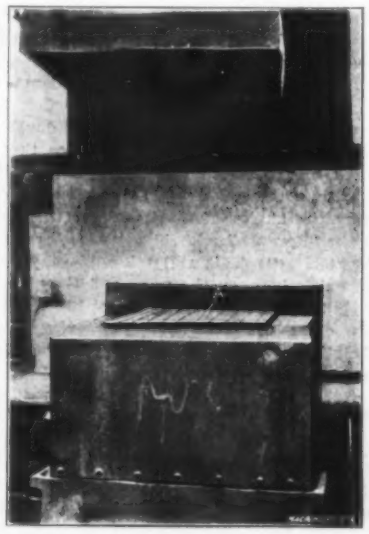


Fig. 4.—Coke Furnace for Heating Bar Magnets for Bending—Bar Magnets Shown at *A*.

CUTTING MAGNET BARS TO REQUIRED LENGTHS.

The bars of magnet steel are obtained of the proper width and thickness, and then are sheared to the short lengths required for the magnets. The shears used for this purpose must be of massive construction, low geared, and provided with a heavy flywheel to overcome the sudden resistance offered by the hard-steel bars. The shaft driving the moving head must be adequately large or it will be twisted off when the shear blade strikes a hard spot in the steel, which frequently happens.

Some form of stop must be provided to accurately gage the length to which the bars are cut off. This stop must be strong and rigid and provided with some means of adjustment in order that it may be varied to suit the required length of the bars to be cut. The stop is usually placed on the opposite side from that at which the bar is fed, so that the operator may quickly push the bar through the jaws of the shear until its movement is arrested by one end of the bar butting against the stop.

The illustration, Fig. 3, shows a shear used for cutting the bars to the length required for the magnet. *A* is the bar of magnet steel, *B* the shearing blades, *C* a guide bar, to prevent the bar from tilting when it is being sheared, and *D* a stop for regulating the length of the piece being sheared. The stop *D* is adjusted along the threaded studs *E*, and when in the desired position is locked by the lock-nuts *F*.

FORGING.

Practically all forms of bar magnets require one or more forging operations, to give them the proper shape. Forging operations on magnets are often termed "heating and bending," or "heating and forming," as the short bars (cut to the proper length by the shear) are heated and then bent to the required shapes. The bars are heated to from 1472 to 1652 deg. F. (according to predetermined temperature tests) in coke, oil, or gas furnaces made especially for this work. The illustrations, Figs. 4, 5 and 7 and Fig. 6 at *A* show the four types of furnaces used. The heating temperature is regulated by electric pyrometers, as shown in Fig. 10. Coke furnaces are rapidly being superseded by oil and gas furnaces, as the later can be more accurately regulated and produce better results.

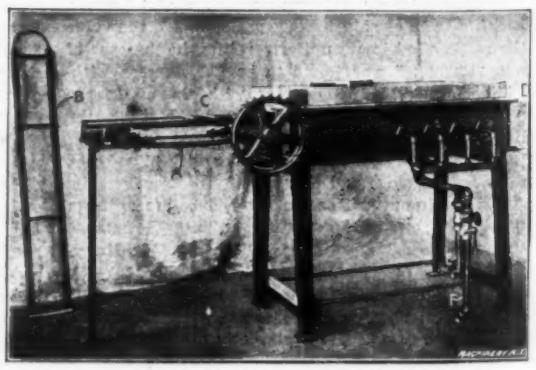


Fig. 5.—Gas Furnace for Heating Bar Magnets for Bending.

The most recent development in this line is a furnace made by the American Gas Furnace Co., shown in Fig. 5. This furnace is equipped with a power-driven endless chain *A* upon which is placed the carrier *B* loaded with the short magnet bars. The carrier moves slowly from left to right, the cold bars entering at *C*, being heated to the required temperature and finally discharged at the rate of about six bars a minute.

After heating, the bars are placed one at a time in some form of power press, usually a very powerful and massive bulldozer or vertical press, as shown at *B*,

Fig. 6. These machines are equipped with special dies (those for forming a U-shaped magnet in a bulldozer being shown in Fig. 10), which bend the bar to the correct shape. Simple magnets such as those of the horseshoe type require only one bending operation, whereas more complicated shapes require two or three bending operations. Extremely irregular

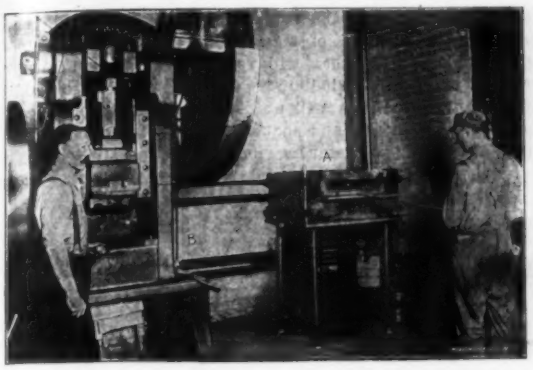


Fig. 6.—Heating and Bending Magnet Forgings in the Sangamo Electric Co.'s Plant.

Fig. 7.—Rockwell Oil Furnace for Heating Magnets Before or After Bending.

by the steel at the high temperature maintained. However, the fault is almost entirely overcome in a furnace constructed as shown in Fig. 11.

Fig. 14 shows a gas furnace similar to the one described for heating magnet bars for bending (Fig. 5). The magnet forgings *A* enter the furnace at *B* and are discharged at *C* at the rate of about four a

Fig. 8.—Grinding Magnet Forgings.

shapes which are not used in great quantity are bent by hand as shown in Fig. 13. This machine consists of a cast-iron die around which a steel roller is revolved by means of a lever to which the roller is

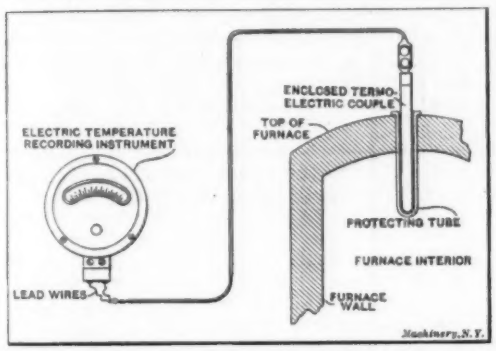


Fig. 9.—Showing Application of an Electric Pyrometer to Magnet Heating Furnace.

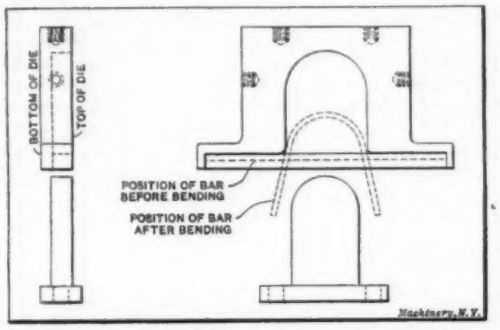


Fig. 10.—Punch and Die Used for Forming U-shaped Magnets in a Bulldozer.

proper lengths as shown in Fig. 8 and drilled or machined if so required by the specifications. After this they are placed in the hardening furnace and brought to a temperature of from 1,500 to 1,600 deg. F. (as

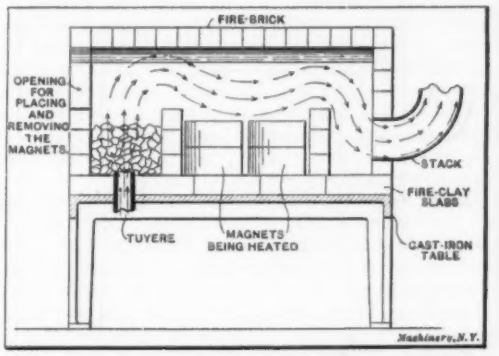


Fig. 11.—Section of Coke Furnace for Heating Magnets Previous to Hardening.

pinned. One end of the hot bar is fastened to the die by a clamping device, so that the bar is held between the roller and the die. The lever is pulled around the die by the operator, causing the roller to press the heated bar against the die, and thus bending the bar to the desired shape.

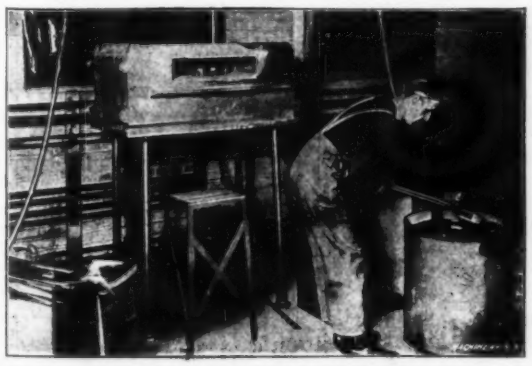


Fig. 12.—Hardening Magnet Forgings in the Sangamo Electric Co.'s Plant.

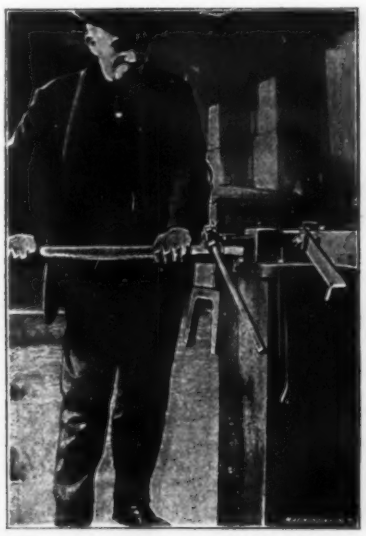


Fig. 13.—Forming Odd-shaped Magnets by Hand.

nace and plunged into cold running water or brine, where they are allowed to remain until cold; they are then removed and piled up ready for grinding and magnetizing. When magnets of very accurate dimensions are required, such as those used on magnetos, the forgings are placed in special tongs with gage-blocks

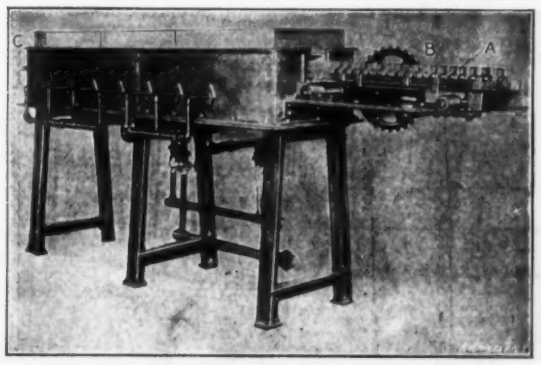


Fig. 14.—A Gas Furnace for Hardening Magnets, Equipped with a Conveyor.

HARDENING.

The forged magnet bars are now allowed to cool slowly in order to prevent crystallization. They are then ground on disk grinders or emery wheels to the

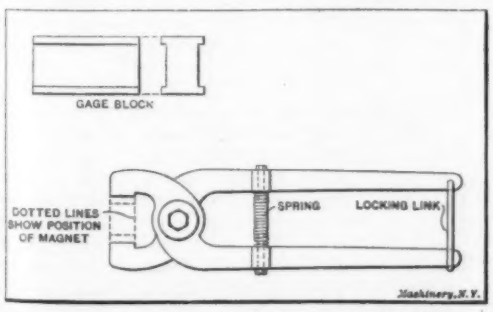


Fig. 15.—Tongs and Gage Block for Holding Magnets While Hardening to Prevent Them from Springing out of Shape.

determined by previous tests). The temperature must be very accurately regulated, as a variation of only a few degrees is likely to injure the steel.

Coke, oil and gas furnaces are used as shown in Figs. 11, 12, and 14. Oil and gas furnaces give the best results, but are more costly and more expensive to operate than coke furnaces. The difficulties experienced with coke furnaces are due to the impurities in the coke, such as sulphur and silicon, being absorbed

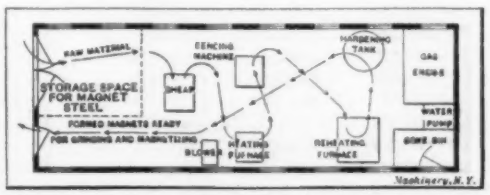


Fig. 16.—Plan of Magnet Forming Department of Hercules Electric Co.—Arrows Indicate Movement of Stock.

between them, as shown in Fig. 15, to prevent them from warping while cooling. Magnet forgings of complicated shape are frequently annealed before hardening, in order to insure uniform heating.

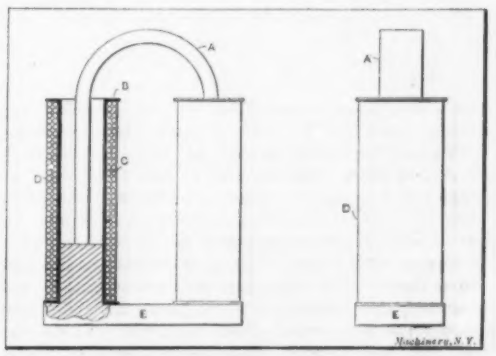


Fig. 17.—Magnetizing a U-shaped Magnet.

GRINDING AND MAGNETIZING.

After being removed from the cooling bath, the forgings are ground to the specified dimensions and all scale and rough edges removed. They are then ready for magnetizing.

Magnetizing is accomplished by means of electromagnets, solenoids, or a combination of the two. One of the most efficient devices for this purpose is shown in Fig. 17, in which *A* is the magnetized, *B* the shell of the solenoid, *C* the winding of the solenoid, *D* the insulating covering, and *E* the malleable iron electromagnetic field piece. While the magnet is being magnetized, the current is rapidly interrupted and the magnet hammered with a rawhide mallet to cause the magnetic molecules to properly adjust themselves. From ten to twenty seconds is usually required for each magnet. This is the last operation required in making permanent magnets. After magnetizing they are ready for use and will retain their magnetism for years under ordinary conditions.

PLATE MAGNETS.

Plate magnets are stamped out of sheet magnet steel 1/16 inch to 5/32 inch thick, by means of ordinary punch presses equipped with hardened steel punches and dies. The process is practically the same as that used for making any form of flat stamping. The stampings require no grinding, drilling or machining before hardening. The method of hardening is similar to that used for other forms of magnets, except that special care must be observed to prevent warping, and to keep the hardening heat from being blanketed by accumulation of scale on the surface. The means used for grinding and magnetizing are similar to those used for bar magnets.

CONCLUSION.

The manufacture of permanent magnets, although a comparatively new industry, has reached a place of considerable importance both from a monetary and scientific standpoint. Its rapid growth may be attributed to the extensive use of this type of magnet in electrical measuring instruments, magnetos, telephones, and recording instruments. The scientific production methods employed are due largely to the constant demand of magneto manufacturers for powerful magnets that will retain their magnetism for an indefinite period under all sorts of adverse conditions, and which will at the same time be absolutely accurate in size and shape. As a whole, few branches of industry represent a more interesting study from a chemical, mechanical, and electrical standpoint than the manufacture of permanent magnets.

Cost of Power; Conversion Factors*

A Useful Table of Derived Units

By Carl Hering

OWING to the fact that the cost of power is sometimes stated in cents per hour and t other times in dollars per year, and that the year is sometimes taken at the rate of 24 hours per day and at other times 10, and that this is further complicated by the power being sometimes stated in horse-powers (and in some foreign countries in metric horse-powers) and at other times in kilowatts, the conversions from any one to another sometimes become tedious and are often liable to errors owing to the difference between a unit and a quantity measured in terms of that unit.

The following table of constants has therefore been determined accurately, giving the values of each in terms of each of the others, so that a single multiplication is all that is required for reducing a cost given in terms of one of them into any of the others, as the reciprocals of all values are always given in their proper places. The constants are arranged in the same style and order as those in the writer's "Conversion Tables" for a new edition of which they have been determined. They are in the order of size, beginning with the smallest. The approximate values, which are sufficiently accurate for many calculations, have been selected so as to minimize calculations.

Two kinds of years have been included, one the complete or full year, of 365¼ days of 24 hours each, and the other a working year of 300 days of 10 hours each, and they have been indicated by the names "full" and "working" respectively.

A horse-power-hour or year is really a measure of a quantity of energy and not of power; but as such quantities are popularly referred to as "power" this term has been used in the title, although not strictly correct.

All the values have been carefully calculated by two independent methods besides being cross checked, and it is believed there are no errors.

COST OF ENERGY; CHARGES FOR POWER; COST OF POWER DURING SPECIFIED TIMES.

NOTE: A "full" year means 24 hours per day and 365¼ days per year = 8766 hours.
A "working" year means 10 hours per day and 300 days per year = 3000 hours.
Aprx. means within 2%.

1 dollar per kilowatt year (full) [$/kw-yr.]:
= 0.745 650 dol. per hp-year (full). Aprx. ¾.
= 0.342 231 dol. per kw-year (working). Aprx. 34 ÷ 100.
= 0.255 185 dol. per hp-year (working). Aprx. 23/9 ÷ 10.
= 0.011 407 7 ct. per kw-hour. Aprx. 8/7 ÷ 100.
= 0.008 506 16 ct. per hp-hour. Aprx. 6/7 ÷ 100.

1 dollar per horse-power-year (full) [$/hp-yr.]:
= 1.341 11 dol. per kw-year (full). Aprx. add 1/3.
= 0.458 971 dol. per kw-year (working). Aprx. 5/11.
= 0.342 231 dol. per hp-year (working). Aprx. 34 ÷ 100.
= 0.015 299 0 cts. per kw-hour. Aprx. 3/2 ÷ 100.
= 0.011 407 7 cts. per hp-hour. Aprx. 8/7 ÷ 100.

1 dollar per kilowatt year (working) [$/kw-yr.]:
= 2.922 00 dol. per kw-year (full). Aprx. 29 ÷ 10.
= 2.178 79 dol. per hp-year (full). Aprx. 11/5.
= 0.745 650 dol. per hp-year (working). Aprx. 3/4.
= 0.033 333 3 ct. per kw-hour. Aprx. 1/3 ÷ 10.
= 0.024 855 0 ct. per hp-hour. Aprx. 1/4 ÷ 10.

1 dollar per horse-power-year (working) [$/hp-yr.]:
= 3.918 73 dol. per kw-year (full). Aprx. 35/9.
= 2.922 00 dol. per hp-year (full). Aprx. 29 ÷ 10.
= 1.341 11 dol. per kw-year (working). Aprx. add 1/3.
= 0.044 703 8 ct. per kw-hour. Aprx. 9/2 ÷ 100.
= 0.033 333 3 ct. per hp-hour. Aprx. 1/3 ÷ 10.

1 cent per kilowatt hour [cts./kw-hr]:
= 87.660 0 dol. per kw-year (full). Aprx. 7/8 × 100.
= 65.363 7 dol. per hp-year (full). Aprx. 65.
= 30. dol. per kw-year (working).
= 22.369 5 dol. per hp-year (working). Aprx. 9/4 × 10.
= 0.745 650 ct. per hp-hour. Aprx. 3/4.

1 cent per horse-power-hour [cts./hp-hr]:
= 117.562 dol. per kw-year (full). Aprx. 7/6 × 100.
= 87.660 0 dol. per hp-year (full). Aprx. 7/8×100.
= 40.233 4 dol. per kw-year (working). Aprx. 40.
= 30. dol. per hp-year (working).
= 1.341 11 cts. per kw-hour. Aprx. add 1/3.

FOREIGN.

The values of foreign moneys here used are those specified in the writer's "Conversion Tables" and are those used by the U. S. Treasury Department. They are the true relative values based on gold, as determined by the U. S. Mint in terms of the U. S. gold dollar. The three fundamental values are: 1 pound sterling = 240 pence = $4.8665; 1 mark = 100 pfennige = $0.238; 1 franc = 100 centimes = $0.193. Those constants which depend upon these money values are given to only three or four significant figures; those independent of them are given to six figures, as usual. It has been assumed that the regular horse-power is the only one used in England (as in the United States) and that the metric horse-power is the only one used in the rest of Europe; when this is not the case two calculations will be necessary. One metric horse-power = 0.986318 horse-power; one horse-power = 1.01387 metric horse-powers; the difference is therefore about 1½ per cent.

1 franc per kilowatt-year (full):
= 0.811 mark per kilowatt-year (full). Aprx. 4/5.
= 0.735 448 franc per metric horse-power-year (full). Aprx. 22/3 ÷ 10.
= 0.342 231 franc per kilowatt-year (working). Aprx. 34 ÷ 100.
= 0.251 693 franc per metric horse-power-year (working). Aprx. 1/4.
= 0.193 dollar per kilowatt-year (full). Aprx. 19 ÷ 100.
= 0.039 7 pound per kilowatt-year (full). Aprx. 4 ÷ 100.
= 0.011 407 7 centime per kilowatt-hour. Aprx. 8/7 ÷ 100.
= 0.008 389 77 centime per metric horse-power-hour. Aprx. 5/6 ÷ 100.

1 mark per kilowatt-year (full):
= 1.23 francs per kilowatt-year (full). Aprx. 1/8 × 10.
= 0.735 448 mark per metric horse-power-year (full). Aprx. 22/3 ÷ 10.
= 0.342 231 mark per kilowatt-year (working). Aprx. 34 ÷ 100.
= 0.251 693 mark per metric horse-power-year (working). Aprx. 1/4.
= 0.238 dollar per kilowatt-year (full). Aprx. 12/5 ÷ 10.
= 0.048 9 pound per kilowatt-year (full). Aprx. 49 ÷ 1000.
= 0.011 407 7 pfennig per kilowatt-hour. Aprx. 8/7 ÷ 100.
= 0.008 389 78 pfennig per metric horse-power-hour. Aprx. 5/6 ÷ 100.

1 franc per metric horse-power-year (full):
= 1.359 72 francs per kilowatt-year (full). Aprx. add 1/3.
= 0.811 mark per metric horse-power-year (full). Aprx. 4/5.
= 0.465 337 franc per kilowatt-year (working). Aprx. 7/15.
= 0.342 231 franc per metric horse-power-year (working). Aprx. 34 ÷ 100.
= 0.196 dollar per horse-power-year (full). Aprx. 8/41.
= 0.040 2 pound per horse-power-year (full). Aprx. 4 ÷ 100.
= 0.015 511 2 centime per kilowatt-hour. Aprx. 31/2 ÷ 1000.
= 0.011 407 7 centime per metric horse-power-hour. Aprx. 8/7 ÷ 100.

1 mark per metric horse-power-year (full):
= 1.359 72 marks per kilowatt-year (full). Aprx. add 1/3.
= 1.23 francs per metric horse-power-year (full). Aprx. 1/8×10.
= 0.465 337 mark per kilowatt-year (working). Aprx. 7/15.
= 0.342 231 mark per metric horse-power-year (working). Aprx. 34 ÷ 100.
= 0.241 dollar per horse-power-year (working). Aprx. 12/5 ÷ 10.
= 0.049 6 pound per horse-power-year (full). Aprx. 5 ÷ 100.
= 0.015 511 2 pfennig per kilowatt-hour. Aprx. 31/2 ÷ 1000.
= 0.011 407 7 pfennig per metric horse-power-hour. Aprx. 8/7 ÷ 100.

1 franc per kilowatt-year (working):
= 2.922 00 francs per kilowatt-year (full). Aprx. 29 ÷ 10.
= 2.148 98 francs per metric horse-power-year (full). Aprx. 43/2 ÷ 10.
= 0.811 mark per kilowatt-year (working). Aprx. 4/5.
= 0.735 448 franc per metric horse-power-year (working). Aprx. 3/4.
= 0.193 dollar per kilowatt-year (working). Aprx. 19 ÷ 100.
= 0.039 7 pound per kilowatt-year (working). Aprx. 4 ÷ 100.
= 0.033 333 3 centime per kilowatt-hour. Aprx. 1/3 ÷ 10.
= 0.024 514 9 centime per metric horse-power-hour. Aprx. 1/4 ÷ 10.

1 mark per kilowatt-year (working):
= 2.922 00 marks per kilowatt-year (full). Aprx. 29 ÷ 10.
= 2.148 98 marks per metric horse-power-year (full). Aprx. 43/2 ÷ 10.
= 1.23 francs per kilowatt-year (working). Aprx. 1/8×10.
= 0.735 448 mark per metric horse-power-year (working). Aprx. 3/4.
= 0.238 dollar per kilowatt-year (working). Aprx. 12/5 ÷ 10.
= 0.048 9 pound per kilowatt-year (working). Aprx. 49 ÷ 1000.
= 0.033 333 3 pfennig per kilowatt-hour. Aprx. 1/3 ÷ 10.
= 0.024 514 9 pfennig per metric horse-power-hour. Aprx. 1/4 ÷ 10.

1 franc per metric horse-power-year (working):
= 3.973 09 francs per kilowatt-year (full). Aprx. 4.
= 2.922 00 francs per metric horse-power-year (full). Aprx. 29 ÷ 10.
= 1.359 72 francs per kilowatt-year (working). Aprx. add 1/3.
= 0.811 mark per metric horse-power-year (working). Aprx. 4/5.
= 0.196 dollar per horse-power-year (working). Aprx. 8/41.
= 0.045 323 9 centime per kilowatt-hour. Aprx. 9/2 ÷ 100.
= 0.040 2 pound per horse-power-year (working). Aprx. 4 ÷ 100.
= 0.033 333 3 centime per metric horse-power-hour. Aprx. 1/3 ÷ 10.

1 mark per metric horse-power-year (working):
= 3.973 09 marks per kilowatt-year (full). Aprx. 4.
= 2.922 00 marks per metric horse-power-year (full). Aprx. 29 ÷ 10.
= 1.359 72 marks per kilowatt-year (working). Aprx. add 1/3.
= 1.23 francs per metric horse-power-year (working). Aprx. 1/8 × 10.
= 0.241 dollar per horse-power year (working). Aprx. 12/5 ÷ 10.
= 0.049 6 pound per horse-power-year (working). Aprx. 5 ÷ 100.
= 0.045 323 9 pfennig per kilowatt-hour. Aprx. 9/2 ÷ 100.
= 0.033 333 3 pfennig per metric horse-power-hour. Aprx. 1/3 ÷ 10.

1 dollar per kilowatt-year (full):
= 5.18 francs per kilowatt-year (full). Aprx. 26/5.
= 4.20 marks per kilowatt-year (full). Aprx. 21/5.
= 0.205 pound per kilowatt-year (full). Aprx. 41/2 ÷ 100.

1 dollar per horse-power-year (full).
= 5.11 francs per metric horse-power-year (full). Aprx. 51 ÷ 10.
= 4.15 marks per metric horse-power-year (full). Aprx. 25/6.
= 0.205 pound per horse-power-year (full). Aprx. 41/2 ÷ 100.

1 dollar per kilowatt-year (working):
= 5.18 francs per kilowatt-year (working). Aprx. 26/5.
= 4.20 marks per kilowatt-year (working). Aprx. 21/5.
= 0.205 pound per kilowatt-year (working). Aprx. 41/2 ÷ 100.

1 dollar per horse-power-year (working):
= 5.11 francs per metric horse-power-year (working). Aprx. 51 ÷ 10.
= 4.15 marks per metric horse-power-year (working). Aprx. 25/6.
= 0.205 pound per horse-power-year (working). Aprx. 41/2 ÷ 100.

1 pound per kilowatt-year (full):
= 25.2 francs per kilowatt-year (full). Aprx. 1/4 × 100.
= 20.4 marks per kilowatt-year (full). Aprx. 41/2.
= 4.87 dollars per kilowatt-year (full). Aprx. 2/41 × 100.
= 0.745 650 pound per horse-power-year (full). Aprx. 3/4.
= 0.342 231 pound per kilowatt-year (working). Aprx. 34 ÷ 100.
= 0.255 185 pound per horse-power-year (working). Aprx. 23/9 ÷ 10.
= 0.027 378 5 penny per kilowatt-hour. Aprx. 3/11 ÷ 10.
= 0.020 414 8 penny per horse-power-hour. Aprx. 1/50.

1 pound per horse-power-year (full):
= 24.9 francs per metric horse-power-year (full). Aprx. 1/4 × 100.
= 20.2 marks per metric horse-power-year (full). Aprx. 1/5 × 100.
= 4.87 dollars per horse-power-year (full). Aprx. 2/41 × 100.
= 1.341 11 pounds per kilowatt-year (full). Aprx. add 1/3.
= 0.458 971 pound per kilowatt-year (working). Aprx. 5/11.
= 0.342 231 pound per horse-power-year (working). Aprx. 34 ÷ 100.
= 0.036 717 7 penny per kilowatt-hour. Aprx. 11/3 ÷ 100.
= 0.027 378 5 penny per horse-power-hour. Aprx. 3/11 ÷ 10.

1 pound per kilowatt-year (working):
= 25.2 francs per kilowatt-year (working). Aprx. 1/4 × 100.
= 20.4 marks per kilowatt-year (working). Aprx. 41/2.
= 4.87 dollars per kilowatt-year (working). Aprx. 2/41 × 100.
= 2.922 00 pounds per kilowatt-year (full). Aprx. 29 ÷ 10.
= 2.178 79 pounds per horse-power-year (full). Aprx. 11/5.
= 0.745 650 pound per horse-power-year (working). Aprx. 3/4.
= 0.080 00 penny per kilowatt-hour. Aprx. 8/100.
= 0.059 652 0 penny per horse-power-hour. Aprx. 6/100.

1 centime per kilowatt-hour:
= 87.660 0 francs per kilowatt-year (full). Aprx. 7/8×100.
= 64.469 0 francs per metric horse-power-year (full). Aprx. 65.
= 30. francs per kilowatt-year (working).
= 22.063 4 francs per metric horse-power-year (working). Aprx. 22.
= 0.811 pfennig per kilowatt-hour. Aprx. 4/5.
= 0.735 448 centime per metric horse-power-hour. Aprx. 3/4.
= 0.596 pfennig per metric horse-power-hour. Aprx. 6/10.
= 0.193 cent per kilowatt-hour. Aprx. 19 ÷ 100.
= 0.144 cent per horse-power-hour. Aprx. 1/7.
= 0.095 2 penny per kilowatt-hour. Aprx. 2/21.
= 0.070 9 penny per horse-power-hour. Aprx. 7/100.

1 pound per horse-power-year (working):
= 24.9 francs per metric horse-power-year (working). Aprx. 1/4 × 100.
= 20.2 marks per metric horse-power-year (working). Aprx. 1/5 × 100.
= 4.87 dollars per horse-power-year (working). Aprx. 2/41 × 100.
= 3.918 73 pounds per kilowatt-year (full). Aprx. 35/9.
= 2.922 00 pounds per horse-power-year (full). Aprx. 29 ÷ 10.
= 1.341 11 pounds per kilowatt-year (working). Aprx. add 1/3.
= 0.107 289 penny per kilowatt-hour. Aprx. 3/28.
= 0.080 0 penny per horse-power-hour. Aprx. 8/100.

1 pfennig per kilowatt-hour:
= 87.660 0 marks per kilowatt-year (full). Aprx. 7/8 × 100.
= 64.469 0 marks per metric horse-power-year (full). Aprx. 65.
= 30. marks per kilowatt-year (working).
= 22.063 4 marks per metric hp-year (working). Aprx. 22.
= 1.23 centimes per kilowatt-hour. Aprx. 1/8 × 10.
= 0.907 centime per metric horse-power-hour. Aprx. 9/10.
= 0.735 448 pfennig per metric horse-power-hour. Aprx. 3/4.
= 0.238 cent per kilowatt-hour. Aprx. 12/5 ÷ 10.
= 0.178 cent per horse-power-hour. Aprx. 7/4 ÷ 10.
= 0.117 penny per kilowatt-hour. Aprx. 7/6 ÷ 10.
= 0.087 5 penny per horse-power-hour. Aprx. 7/8 ÷ 10.

1 centime per metric horse-power-hour:
= 119.193 francs per kilowatt-year (full). Aprx. 120.
= 87.660 0 francs per metric hp.-yr. (full). Aprx. 7/8 × 100.
= 40.791 5 francs per kilowatt-year (working). Aprx. 40.
= 30. francs per metric horse-power-year (working).
= 1.359 72 centimes per kilowatt-hour. Aprx. add 1/3.
= 1.10 pfennig per kilowatt-hour. Aprx. 11 ÷ 10.
= 9.811 pfennig per metric horse-power-hour. Aprx. 8/10.
= 0.263 cent per kilowatt-hour. Aprx. 5/19.
= 0.196 cent per horse-power-hour. Aprx. 8/41.
= 0.129 penny per kilowatt-hour. Aprx. 13 ÷ 100.
= 0.096 4 penny per horse-power-hour. Aprx. 2/21.

1 pfennig per metric horse-power-hour:
= 119.193 marks per kilowatt-year (full). Aprx. 120.
= 87.660 0 marks per metric hp-yr. (full). Aprx. 7/8 × 100.
= 40.791 5 marks per kilowatt-year (working). Aprx. 40.
= 30. marks per metric horse-power-year (working).
= 1.68 centimes per kilowatt-hour. Aprx. 1/6 × 10.
= 1.359 72 pfennige per kilowatt-hour. Aprx. add 1/3.
= 1.23 centimes per metric hp.-hr. Aprx. 1/8 × 10.
= 0.324 cent per kilowatt-hour. Aprx. 32/100.
= 0.241 cent per horse-power-hour. Aprx. 24/100.
= 0.160 penny per kilowatt-hour. Aprx. 16/100.
= 0.119 penny per horse-power-hour. Aprx. 12/100.

1 cent per kilowatt-hour:
= 5.18 centimes per kilowatt-hour. Aprx. 26/5.
= 4.20 pfennige per kilowatt-hour. Aprx. 21/5.
= 3.81 centimes per metric horse-power-hour. Aprx. 19/5.
= 3.09 pfennige per metric horse-power-hour. Aprx. 31 ÷ 10.
= 0.493 penny per horse-power-hour. Aprx. 1/2.
= 0.368 penny per horse-power-hour. Aprx. 4/11.

1 cent per horse-power-hour:
= 6.95 centimes per kilowatt-hour. Aprx. 7.
= 5.64 pfennige per kilowatt-hour. Aprx. 4/7 × 10.
= 5.12 centimes per metric horse-power-hour. Aprx. 51 ÷ 10
= 4.15 pfennige per metric hp.-hr. Aprx. 25/6.
= 0.662 penny per kilowatt-hour. Aprx. 2/3.
= 0.493 penny per horse-power-hour. Aprx. 1/2.

1 penny per kilowatt-hour:
= 36.525 0 pounds per kilowatt-year (full). Aprx. 36.
= 27.234 9 pounds per horse-power-year (full). Aprx. 27.
= 12.500 0 pounds per kilowatt-year (working). Aprx. 1/8×100.
= 10.5 centimes per kilowatt-hour. Aprx. 21/2.
= 9.320 62 pounds per horse-power-year (working). Aprx. 65/7.
= 8.52 pfennige per kilowatt-hour. Aprx. 17/2.
= 7.73 centimes per metric horse-power-hour. Aprx. 31/4.
= 6.26 pfennige per metric horse-power-hour. Aprx. 25/4.
= 2.03 cents per kilowatt-hour. Aprx. 2.
= 1.51 cents per horsepower-hour. Aprx. 1-1/2.
= 0.745 650 penny per horse-power-hour. Aprx. 3/4.

1 penny per horse-power-hour:
= 48.984 2 pounds per kilowatt-year (full). Aprx. 49.
= 36.525 0 pounds per horse-power-year (full). Aprx. 36.
= 16.763 9 pounds per kilowatt-year (working). Aprx. 1/6 × 100.
= 14.1 centimes per kilowatt-hour. Aprx. 1/7 × 100.
= 12.500 0 pounds per horse-power-year (working). Aprx. 1/8 × 100.
= 11.4 pfennige per kilowatt-hour. Aprx. 8/7 × 100.
= 10.4 centimes per metric horse-power-hour. Aprx. 21/2.
= 8.41 pfennige per metric horse-power-hour. Aprx. 1/12 × 100.
= 2.72 cents per kilowatt-hour. Aprx. 11/4.
= 2.03 cents per horse-power hour. Aprx. 2.
= 1.341 11 pence per kilowatt-hour. Aprx. add 1/3.

*Reprinted from *Metallurgical and Chemical Engineering*.

The East Coast Petroleum Fields of New Zealand

A Concise Survey of the Situation

THE prospects and probabilities of petroleum being discovered in payable quantities in the Poverty Bay—or perhaps more correctly the East Coast—district of the North Island of New Zealand, have been dealt with to a great extent in the following published reports:

1901—"Report on the Petroleum-bearing Rocks of Poverty Bay and East Coast Districts," by A. McKay.

1907—"Report on East Coast Petroleum Fields," by F. A. Rich.

1908—New Zealand Geological Survey Department Annual Report.

1910—New Zealand Geological Survey—Bulletin No. 9, "The Geology of the Whatatutu Subdivision."

1910—"Geological Report on the Poverty Bay District and Its Oil Prospects," made for the New Zealand Oilfields, Ltd., by H. Hill, B.A., F.G.S.

There are many others on the same subject but there is still a great deal to be said, and all those qualified to judge anticipate success from operations carried on scientifically and with ample capital. It is quite easy to discern the reasons for the failures in the past. Those reasons were mainly the lack of sufficient capital and the want of properly qualified men to supervise and conduct operations. These remarks may in some measure explain the disappointments which have hitherto followed the operations of the locally formed Gisborne Oil Company, which though striking a vein of good quality oil at 655 feet on the Waitangi anticline were unable to proceed deeper with the well to reach the secondary or tertiary strata owing to the small size of the bore which had, contrary to expert's advice, been adopted.

In 1874 the Poverty Bay Petroleum and Kerosene Company commenced operations on land known as the Pakake-a-whirikoka Block, with a driller to supervise the operations of an old-fashioned primitive plant. This company failed to locate payable wells, but it is now known that at the position chosen (about 1,450 feet above sea-level) there is oil in considerable quantities. Indeed, 30 years ago a spring of oil was struck which yielded from 8 to 10 gallons per diem, and this flow was obtained without striking the bed rock at all.

A few years later the South Pacific Petroleum Company worked the same ground with somewhat more success. Nine shallow wells were sunk, but though gas and oil were found in the bores, they were not continued to a greater depth than 400 or 500 feet. The location of these wells was to the northeast of the Waitangi Station—a small area of ground included them all. Other attempts were made by this company in the same neighborhood at a lower altitude. In 1884 the machinery was moved to a fresh location on the Wairangaremia River. Another bore was sunk but owing to the primitive nature of the plant and smallness of the casing the company only reached 1,320 feet with 4½ inch casing. It was at this well that in December, 1887, a "blow-out" of oil took place which burned down the derrick. The burning oil continued to play up and down like a fountain, to a height of 24 feet, for some days. All the available capital having been spent, the shareholders became dissatisfied, and the plant was disposed of to meet liabilities.

The Minerva Petroleum Company started a well in 1888 on the bank of the Waipaca River at Mangataikapua near Whatatutu. This well raised great hopes of ultimate success but it had to be abandoned—principally from mishaps to the bore through bad drilling. Where the gas flow was regulated a continuously burning flame could be obtained over two feet in height from a linepipe sunk to a depth of about 700 feet. At 750 feet a brown shale impregnated with oil was met. Again the small diameter of the casing at this depth prevented further sinking, though the prospects were considered highly satisfactory, but the needful capital was not forthcoming.

In 1901 an English syndicate, after an examination of various localities with the government geologist, decided to sink two trial bores at Tangihanga near the Totangi Stream. Work was commenced in 1903. The drilling was conducted by an artesian well-driller, who commenced the first bore with 3-inch casing, and the second with 4-inch casing, with the result that he only got down 300 feet and 500 feet, respectively. There is a strong and active seepage of good quality oil upon this property, and the New Zealand Oilfields, Ltd., have already commenced to sink a large well on this property.

The Southern Cross Petroleum Company in 1881 undertook boring operations on the Rotokautuku Block, 70 miles north of Gisborne, near the Waiapu River. Seven wells were drilled, ranging from 150 feet to one of 1,820 feet. Five of these were on a tableland, the foothill of a higher range of mountains forming the backbone of the East Cape country. This position was chosen because of the surface indications of gas, oil, and ozokerite, but none of these wells reached more than a moderate depth on account of faulty drilling. In 1883 another position was selected to the northeast of the previous base of operations, and another feeble attempt was made. At about 400 feet a hard band of crystalline rock was encountered, lying in the blue-gray shale formation, followed by a mud vein at about 180 feet lower, which eventually caused the work to be discontinued. Another site was located on a river flat a mile and three-quarters southwest of the original workings, and the depth reached was 1,820 feet. Gas was met at 170 feet; sandstone with gas and oil at 1,000 feet and 1,200 feet; but after reaching 1,820 feet the well was abandoned although the indications were good. Again the trouble was want of capital.

All these failures were attributed to primitive plant, bad drilling, and the want of geological knowledge in the definition of anticlines and synclines.

As may be seen from a perusal of the various reports referred to in the opening paragraph, oil seepages, salt springs, inflammable gas springs, and mud springs abound thoroughout the district from the East Cape in the north to the Mahia Peninsula in the south, and inland from the coast to the Ruakumara Mountains. The report of the eruptions of the Waimaia mud springs in the Government of New Zealand *Mines Record* of October 16th, 1908, is particularly interesting in this connection.

Now that the district has been examined by various well-known experts, among others by Dr. Wanner, Mr. J. D. Henry, Dr. J. M. Bell, Mr. F. A. Rich, and the experts of the New Zealand Oilfields, Ltd., the most sanguine expectations are entertained by those qualified to judge that this district will prove one of the most extensive and prolific oilfields in the empire.

Concessions comprising approximately 150,000 acres were disposed of by Mr. W. Lissant Clayton to the New Zealand Oilfields, Ltd., last year, and are very favorably situated. This is the first joint-stock company to undertake the prospecting for oil in a proper manner in the Poverty Bay district, and it is understood that their experts are most sanguine as to the prospects of success. The first derrick has been erected and the most modern machinery installed and a start made to put down a 14-inch bore on this company's Totangi concession, about 16 miles from the port of Gisborne, while various test bores are being sunk in the neighborhood of the main bore. In one of these test bores at a depth of 250 feet, a strong pressure of gas has been met with, and the formation is saturated with petroleum. The site for the second large bore has been located on another of the company's concessions situated at Ormond, about eleven miles by railway or road from Gisborne. The derrick and buildings are nearly completed on this site, and practically all the necessary machinery and casing is now on the spot.

It may be noted that while the shares in the New Zealand Oilfields, Ltd., were at a premium on issue, they depreciated in London owing to the downward tendency of the oil market generally, but sales in the Dominion have been taking place up to the present date at two shilling one penny, and have never once been below this price, thus indicating the confidence of New Zealand investors. Now the London market is improving, prices in the Dominion are also better.

Mr. W. Lissant Clayton has acquired further concessions than those disposed of by him to the New Zealand Oilfields, Ltd. These more recent concessions are over upward of 300,000 acres in the Poverty Bay District, and are now under the consideration of London financiers. Having been selected in the light of recent explorations, these concessions are on known or probable anticlines, besides being generally nearer the coast and more accessible than some of those already dealt with, as will be observed by a study of the map. Most are within easy distance of the port of Gisborne, and some are within the vicinity of the Mahia Peninsula and within easy access of Waikokopu Harbor—a fine natural haven in which ocean-going boats can lie. The local bodies throughout the coastal districts referred to are anxious to assist in the establishment of the oil industry, and as they have legal powers to grant facilities for laying light tram and pipe lines along the country roads, their assistance may be expected in the direction indicated.

Aviation and Arterial Pressure

THE constantly increasing application of the aeroplane to such practical uses as cross-country flying, the delivery of letters and parcels, the location of submarine boats and mines by reconnoitering above the water (a feat recently successfully accomplished in France), and the carrying of passengers, directs attention anew to the importance to the aviator of an exact knowledge of the powers and the limitations of his own body.

Marvelous as is the human machine in its powers of recuperation after injury or strain, it has the disadvantage that it cannot be reassembled when once shattered, and worn-out portions cannot be replaced by new ones ordered from a factory—facts that reckless young aviators are apt to ignore.

Of especial importance is it to the aviator to know the condition and capacity of his heart and arteries, because of the severe strain put on them by the rapidity of movement, the fluctuations of air-pressure, the concentration of attention demanded, and the ever possible violent excitement of sudden danger.

If "the motor is the heart of the flying-machine," the heart is the motor of the human machine, and in either case a defective motor is the gravest source of catastrophe.

Altitude flying has a peculiarly disturbing effect on the heart, not only because of its intimate association and co-operation with the lungs, but because of the variations in arterial pressure produced by changes in the density of the atmosphere, and the fact that the tremendous rapidity of ascent and descent does not afford time for the proper adjustment of the internal to the external pressure. It has been said that the torpor which affects some aviators in too swift ascent or descent, and which is held responsible for many fatal accidents, comes from insufficient responsiveness of the arteries to changed pressure conditions, and this is easy to comprehend, since whatever affects arterial pressure must affect the supply of blood to the brain.

In this connection a very curious and significant discovery has just been anounced by Dr. P. Bonnier. It has long been known that the *medulla oblongata*, the bulbous mass of gray and white nerve matter situated at the top of the spinal cord, governs the involuntary actions of heart and lungs. This is the reason why injuries to the neck are so uniformly fatal in nearly all instances, while life may be prolonged for years when other portions of the spinal cord or the brain itself have been injured. Dr. Bonnier has now shown the existence in the *medulla* of manostatic centers whose function it is to produce an equilibrium between the interior pressure of the blood and the exterior pressure of the atmosphere.

Furthermore, in subjects whose arterial pressure is supernormal because of defective action of the nerve centers, he has proven the possibility of rousing the activity of these by means of a very simple operation, consisting of a slight nasal cauterization at a point connected with the area of the *medulla* where the centers in question are found.

The return of the arterial tension to the normal following the operation is often immediate and seems to be permanent, though judgment must be suspended on this point until the early experiments are confirmed.

However, Dr. Bonnier cites one case of great interest—that of a young man who suffered from circulatory oppression and dizziness at each descent. His arterial tension was regulated and reduced from 22 to 16, a tension which has been normally maintained ever since (a period of four months at the time of writing), with the result that he has experienced only a slight discomfort in place of his former oppressive sensations during descent.

Thus it would seem that in some instances, at any rate, the aviator may be able to control his arterial tension and "regulate his manostatic capacity with as much care as his motor."

Hydrate of Aluminium in the form of a loose, ungelatinous powder, may be obtained by dissolving 1,000 parts of alum and 5 parts of blue vitriol, in 5,000 parts of water, and introducing a piece of sheet zinc about 250 parts by weight. After about 3 days, almost all the hydrate of aluminia will have been deposited.

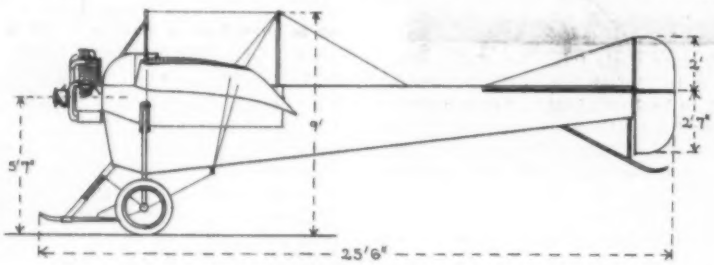
The R. E. P. Monoplane

The Latest Model, With All-Steel Body

By John Jay Ide

ROBERT ESNAULT-PELTERIE ranks with Louis Blériot as one of the first men to fly monoplanes. After having conducted a series of interesting gliding experiments in 1906 he constructed a monoplane with which he made several short flights in October, 1907. A second machine was built in 1908 and was exhibited at the first Aeronautical Salon at Paris in December of that year. This aeroplane was described in the SCIENTIFIC AMERICAN SUPPLEMENT No. 1819, November 12th, 1910.

Three *R. E. P.* monoplanes were entered in the 1909 Reims meet but did not fly to any great extent. During 1910 M. Esnault-Pelterie greatly improved the motor and mounted it on a monoplane built more on standard lines. This machine, shown at the Aeronautical Salon last October, immediately jumped into the very first rank. In the hands of Pierre Marie Bournique it made a remarkable flight for the Michelin Prize on December 31st, covering 530 kilometers (329.3 miles) in 6 hours, 29 minutes, 19 1/5 seconds. The world's records which Bournique raised from 250 to 500 kilometers still stand to the credit of the *R. E. P.*, as do the distances covered in four, five and six hours. Laurens made some passenger records last spring on the Type *D* two-seater, but these have been superseded by the performances of Nieuport.



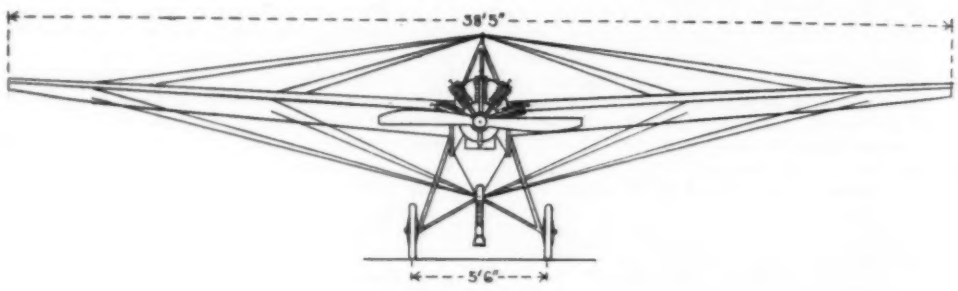
Side Elevation.

In the summer M. Esnault-Pelterie brought out a new model in which the empennage and undercarriage have been considerably modified. Three of the new single-seaters were entered in the European Circuit with Bobba, Amerigo and Gibert as pilots. Bobba completed only one stage and Amerigo fell and was badly injured when starting on the third stage. The reputation of the firm was, however, saved by Gibert who, although handicapped by misfortunes at the start, won the Liege-Utrecht stage, made the fastest time between Calais and Dover, and, on reaching Paris, was placed fifth in the general classification. His total time was 89 hours, 42 minutes, 34 3/5 seconds as compared with Beaumont's 58 hours, 38 minutes, 0 4/5 seconds. Gibert's performance is remarkable for the fact that the same aeroplane and motor were used from start to finish.

The latest *R. E. P.* production, illustrated herewith, is the new Type F two-seater differing from the European Circuit Type only in its dimensions. The outstanding feature of the new model, as of all *R. E. P.* machines, is the solidity of the construction. An examination of the body, undercarriage, will reveal the fact that strength takes precedence over lightness.

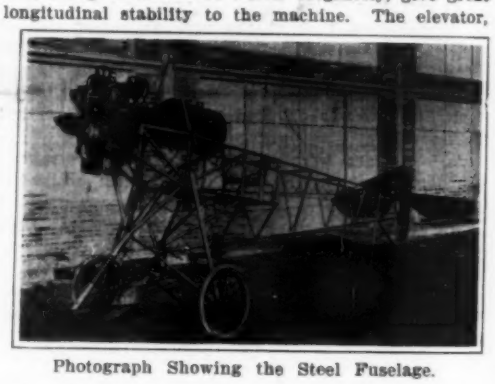
The fuselage, contrary to general practice, is entirely metallic. It is composed of steel tubes connected by welded joints, the whole strongly trussed. This construction renders the frame absolutely rigid, obviates warping, and permits each member to be exactly proportioned to its work.

Each wing is composed of two ash spars of *H*-section joined by ribs on which is stretched the red Continental fabric. The method of attaching the wings to the fuselage is peculiar to the *R. E. P.* In most monoplanes the ends of the spars are let into the fuselage but in the case of the machine under discussion they are attached to the body by means of joints. This prevents the portions of the wings near the fuselage from having to endure abnormal stresses due to their attachment in case the supporting stays should become slack. This arrangement also permits the dihedral angle between the wings to be varied slightly. The lower stays of the rear spar are attached to an oscillating lever mounted on ball bearings and controlled by the wing warping lever. The lower stays attached to the front spar and supporting the wings in flight are steel cables covered with cloth and very strongly attached to the fuselage. The upper stays, which have the weight of the wings to support only when the machine is on the ground or landing, are of steel wire.

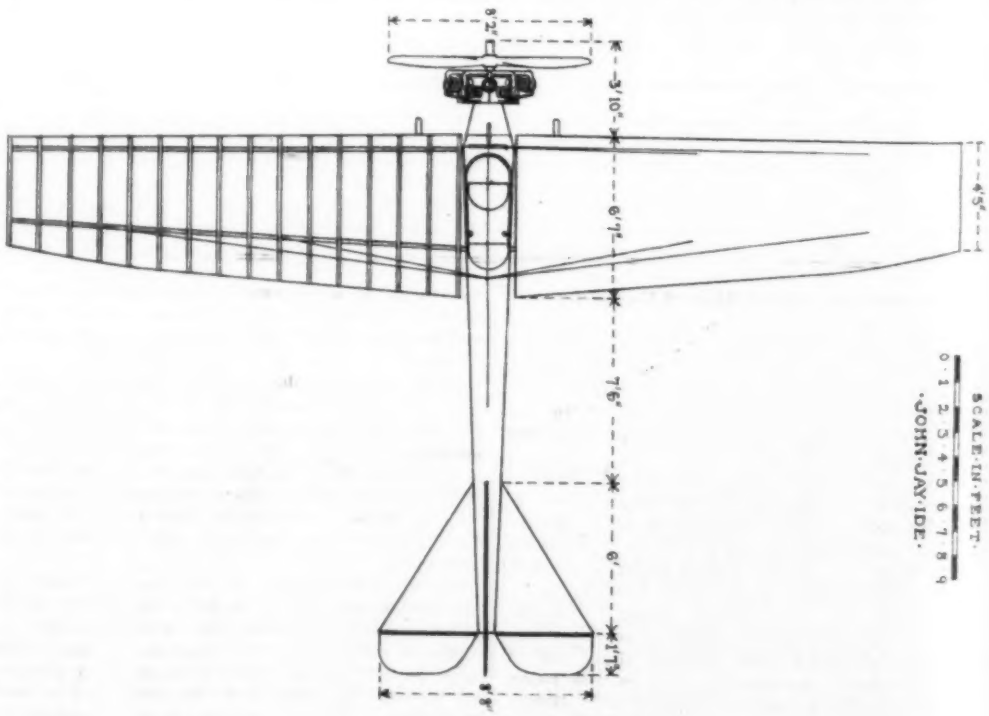


Front Elevation.

The tail fins, elevator, and rudder are demountable; they are composed simply of steel tubing covered with fabric. The well developed horizontal tail fins, being far from the center of gravity, give great longitudinal stability to the machine. The elevator, which forms the prolongation of the horizontal empennage, or tail, is divided into two parts by the rudder forward of which is the verical keel.



Photograph Showing the Steel Fuselage.



Plan.

The undercarriage is composed of the following members:

First. A large central skid of wood covered with cloth projecting forward sufficiently to protect the Régy tractor screw and joined to the fuselage by an oleo-pneumatic brake. In the first series of 1911 machines the rear end of the skid was carried up to meet the body but in the new models it is cut off short as illustrated. The brake, capable of absorbing any shocks up to 2,800 pounds, does not come into action except in landings which are too sudden or which take place on bad ground.

Second. Two independent wheels. In the earlier 1911 models these wheels were connected by an axle but it has now been suppressed and each wheel acts independently of the other. The new system is more logical than the old for the reason that in landing the two wheels never touch the ground simultaneously. Shocks which the wheels receive are taken up by rubber springs at the junction of the struts with the body.

Third. A light skid to carry the tail. The controls of the machine are based upon the instinctive movements of the pilot. A lever for the left hand operates the elevator by a to-and-fro motion and the wing-warping by a transverse motion. A right-hand lever controls the rudder by a side-to-side movement. Particular care has been taken to prevent accidents caused by the failure of the controls which, in the case of the elevator and rudder, are steel rods mounted in duplicate. To the two levers which control the aeroplane itself must be added the means of controlling the motor. These are: first, an ignition advance, and second, a throttle control. Unlike the Gnome, the *R. E. P.* motor can be throttled down to a very low number of revolutions per minute. In making a volplane the pilot does not have to cut off the ignition but simply closes the throttle, thus obviating the possibility of the motor not regaining its speed as quickly as necessary. The throttle control consists of two pedals connected to a lever whose normal position corresponds to the ordinary speed of the motor in flight. Pressing one pedal increases, and pressing the other decreases, the speed in relation to the set limit.

The motor, a 60-horse-power *R. E. P.*, has its five cylinders arranged fan-like around the crank case. The complete cycle takes place in two revolutions, there being 144 degrees between successive explosions. The crankshaft has two throws, one being for the three cylinders in the front row and the other for the two in the rear. The bore and stroke of the cylinders are 110 x 160 millimeters (4.3 x 6.3 inches). The ignition consists of a Bosch high-tension magneto and a battery to facilitate starting. The tanks placed immediately behind the motor carry enough fuel for two hours' flight. The engine is equipped with an air-pump permitting the employment of extra pressure feed tanks when the supply contained in the gravity-feed tanks is not sufficient.

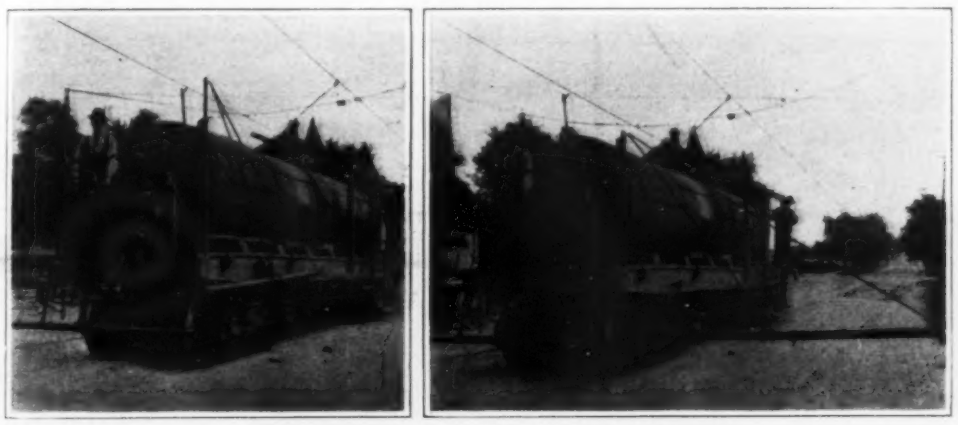
The pilot sits in the rear seat and has all the controls under his hand. The forward seat intended for the passenger is so placed that his presence or absence does not alter in the least the equilibrium of the machine.

In school machines the pupil works two control levers connected with those of the instructor. The latter, however, can throw the pupil's levers out of action whenever necessary. To prevent the aviators from being thrown out of the machine, in case it falls, each occupant is provided with a large elastic belt which absorbs the shock and reduces to the minimum the chance of injuries. The head resistance of the fuselage is very slight on account of its general shape and the fact that it is entirely inclosed in fabric. The weight in flight is about 1,400 pounds and as the surface of the wings is 200 square feet, the loading is seven pounds per square foot. The speed of the machine is just under 60 miles an hour.

Car for Oiling Streets*

The Road Sprinkler Adapted to a New Function

THE interurban lines of the Milwaukee Electric Railway and Light Company pass through the streets of a number of small towns and the company has inaugurated the plan of oiling the streets once or twice a year in preference to sprinkling them with water. To do this work a road-oiling car has been designed and built by the maintenance of way department of the company. This car, which is illustrated herewith, carries a 4,000-gallon tank for holding road oil. It is equipped with oil-distributing pipes and regulating valves, and is designed so that it will spread the oil a width of 36 feet.



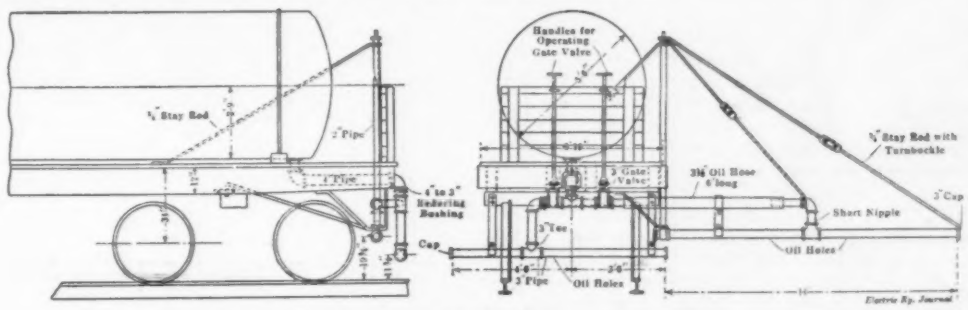
Tank Car with Boom Close to Car and Extended.

Oil is taken from the bottom of the large tank through a tree-connection and two valves, one leading to a horizontal distributing pipe directly over the tracks and the other to a distributing pipe supported as a boom and designed to oil the roadway outside of the track space. One engraving shows the distributing pipes as arranged for oiling to the curb line and the other shows them as arranged for oiling only the track space.

The crew of the oil car consists of a motorman, a trolley man and a valve man. The last watches the speed of the car and the condition of the highway and regulates the supply valves according to the need of the street surface and speed of the car. Ordinarily the oil is spread with the car moving at about three miles per hour. A little over one-half gallon of road oil, at 3 cents a gallon, is used per square yard of street.

The distributing pipes permit the oil to escape through a series of small holes on the under side. These oil holes are graduated in size and spacing, according to the distance from the infeed, so that as the pressure is reduced near the end of the pipe the holes are larger and closer together. Thus an even distribution of oil is secured. The holes in the distributing pipes directly over the track rails are wound with tape. The long pipe supported t the side of the car is hung from a mast arm and is connected with the oil supply through a piece of hose. This pipe is so supported that it can be swung alongside of the car and raised above the truck level to permit operation around sharp curves.

F. G. Simmons, superintendent of construction and maintenance of way, states that no trouble has resulted from slippery rails following the oiling of the streets. As soon as the oil car has covered its streets a sand car follows and both rails are sanded. The line drawing shows the dimensions and piping arrangement at one end of the car.



Side and End Elevations of Milwaukee Oil Tank Car.

* Reproduced from the *Electric Railway Journal*.

Researches in the Use of Cement.

SHRINKAGE of cement is a phenomenon which has a great importance in carrying out all kinds of cement or reinforced concrete work. In actual practice the constructors are familiar with it, as they are often observed to cover the freshly finished work with wet sacks in order to keep them from drying too quickly and producing a shrinkage which would result in cracks in the cement. On account of the practical interest which is presented by the shrinkage of cement, the matter needed investigation in a scientific way, and such researches have in fact been carried out not long since by two French scientists, J. Bied and R. Amic. They explained their results at a recent meeting of the international association for testing of building materials. Their researches bore upon cements coming from different places and of various qualities of fineness, also upon cements mixed with other products, cements prepared with greater or less amounts of water, then exposed to dry or moist air or else placed in gases such as carbonic acid gas. In short, the authors tried to realize all the different conditions which may be met with in actual practice or which are likely to give some useful data. They operated with thin plates of zinc, putting on these a 0.06 inch layer of cement. When the cement shrinks it makes the plates bend, and by measuring the amount of curvature the value of the shrinkage can be obtained. Some of their results may be stated. It is found that the shrinkage of the cement increases with the fineness of grinding. The amount of water used in preparing it has hardly any influence on the contraction.

Quick setting cements shrink almost as much as the slow setting kinds. A short exposure to damp air appears to increase the shrinkage, and to lessen the contraction a long exposure is needed. This latter point is the one which is recognized in practice by covering the work with wet sacks. It is also found that a previous exposure in an atmosphere of damp carbonic acid gas acts to give a great lessening of the shrinkage. Mixing the cement with inert matter such as sand and other material will diminish the shrinkage. The use of caseine mixed with the cement acts invariably and increases or lessens the contraction according to the amount which is used. Formate of soda, from 5 to 10 per cent, lessens the shrinkage, and this is the same for some other salts. It is also true for petroleum. As to the use of caseine, which was formerly employed for coating layers in order to receive fresco painting, the results are variable, as already mentioned. In 1 or 2 per cent, it much lessens the shrinkage of cement, but at 3 per cent it increases it, and even more strongly at 5 per cent. This material makes the mixture fluid and thus causes the cement to flow. The authors are engaged in continuing their researches and there is no doubt that their results will be of great value in practical work, especially as the use of cement is on the increase.

An Excursion Into Physiological Chemistry

Review of the Trend of Modern Progress

UNDER this title, Dr. A. Zart, writing in *Kosmos*, gives a brief review of some of the salient points in the field of modern physiological chemistry. The writer remarks how that chemistry, as opposed to physics, deals with much more intangible processes. To quote in essence his own words: "The difference between physical and chemical transformations never struck me so forcibly as upon visiting modern industrial plants. In a mechanical plant the eye follows with intelligent comprehension the motion of the several parts and traces the aptly designed processes to their conclusion, where the finished product is turned out. How different is the situation in a chemical factory, here we pass by kettles, vats, and other strange apparatus which strike us at most, perhaps, by their size or fantastic shape. A layman peeping in sees great masses in motion, seething and steaming and eddying; he may watch a dye in the process of formation; but without a chemist to explain the process he will be quite in the dark as regards the transformations of matter which are going on there in that vessel.

"Just such chemical factories, only infinitely more complicated, are the living organisms. For, while in an industrial plant large quantities of material of uniform character are worked up into equally uniform products, the most complicated transformations are carried out by plants and animals, in an astonishing small space. And, what is worse, nature has not supplied with this plant a chemist who should take us around and tell us what are the materials that are being worked up, here maintaining bodily warmth, here building up new living matter, and so on, fulfilling the infinitely varied functions incidental to life. If we desire to fathom the problem of this remarkable factory, we must begin at the very bottom and find out first of all what are the materials undergoing transformation; then we may be ready to investigate their relation with the general life phenomena. All this is the task of physiological chemistry, which forms the foundation for scientific dietetics, and for medical science, as applied to man and beast.

'Let us briefly glance at some of the main questions which thus present themselves.

"We may first of all consider that great energy source upon which life's stream depends—the transformation of the radiant energy from the sun by the plant into chemical energy, which is stored up in the form of sugar, starch, fats, etc. By the combustion of these within our body through the action of the oxygen which we take in with our breath, our living machine is kept going. In the language of the chemist, the combustion process of sugar, for example, is schematically represented by the reaction equation

$$\underset{\text{sugar}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \longrightarrow \underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O}$$

If we reverse the direction of the arrow we obtain

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

which represents similarly the process of carbon dioxide dissimilation, i. e., the activity of plants, whereby carbon dioxide and water, under the influence of the sun's rays, are built up into carbohydrates. This reaction equation, however, tells us merely what are the initial and final products: Regarding the mysterious mechanism by which the change is effected, it leaves us absolutely in the dark. The sugar molecule is comparatively complex, and there must be quite a number of intermediate products formed as stepping stones in the process. A number of hypotheses have been framed to indicate the nature of the successive steps. Thus, for instance, V. Baeyer supposed that the first product is formaldehyde. This assumption seems to be borne out by recent experiments, which show that green plants are capable of working up formaldehyde in place of carbon dioxide into sugar and starch. Furthermore, it has been claimed that formaldehyde can be actually detected in some leaves during the process of assimilation. If we accept this theory of formaldehyde as an intermediate product in the formation of carbohydrates in leaves, the entire process now appears split up into two, as follows:

$$CO_2 + H_2O \longrightarrow CH_2O + O_2$$
$$6CH_2O \longrightarrow C_6H_{12}O_6$$

The second portion of this transformation, the conversion of the formaldehyde into carbohydrate, probably itself represents the final result of a more or less complicated series of steps. Thus, for example, there are probably first formed simpler polymerization products containing, say, three carbon atoms. These are regularly built up into sugar molecules, which in their turn are polymerized into starch. This latter being insoluble, represents a reserve material. At the proper season, especially at night, when, in the absence of the sun's rays, assimilation is arrested, this starch is again converted into soluble sugar and is then transported to various reserve quarters, or to points of consumption. This transportation probably takes place in this manner, that the sugar, being present in the leaves in comparatively concentrated solution, diffuses to other parts of the plant, where the solution is more dilute.

"It may be mentioned in passing that the conversion of formaldehyde into sugar had been successfully carried out in the laboratory. The sugar so obtained, however, was not identical with that found in plants. Another remarkable problem which should naturally find mention here, is the fact that most of the substances elaborated by plants, are optically active, owing to a peculiar asymmetric structure of their molecules, while the substances prepared artificially are optically inactive.

"The mysterious seat of all these processes, of such surpassing importance for us, is the green coloring matter of leaves, so-called chlorophyll. Much work has been done to elucidate the chemical nature of this substance. But even at the present the problem cannot be said to be completely solved. A rather remarkable fact which has come to light, is that chlorophyll contains magnesium, a metal whose significance in organic synthesis is well known in the laboratory. Another astonishing disclosure regarding chlorophyll, is its close relationship to hæmoglobin, the red coloring matter of the blood. Both contain the so-called pyrrol ring.

"As to the deeper significance of this relationship we can only make conjectures. It is remarkable that the two bodies thus closely allied chemically, fulfill in nature as it were diametrically opposite functions—the green chlorophyll of the plant represents the constructive, synthesizing principle, while the red hæmoglobin of the blood functions as storer and carrier of the destructive element oxygen.

"Another department of physiological chemistry which is of supreme importance, and has of late years been greatly furthered by the masterly work of Emil Fischer (the same who in earlier years unraveled the constitution of the sugars) is the chemistry of the albuminoids or proteids. In this field our knowledge is, if anything, even more scant than in those considered above. True it is that we know that albumen also can be built up only by plants, while animals have merely the faculty of breaking it down, or at best transforming it. But how the plant works up into albuminoids the nitrogen which it collects from the air or from the soil, on this question we are practically in total ignorance. Again, while the constitution of the sugars has been very fully worked out, in the case of albumen, we are but on the threshold of understanding; this, however, is only the more reason why our interest should be focused upon this problem. So far as ultimate composition is concerned, albumen consists of carbon, hydrogen, oxygen, nitrogen, etc. The mere problem of isolating any one albuminoid in purity is the first difficulty that appears, and in fact it is quite doubtful whether such isolation has ever been effected. All that we can do at present is to form some sort of idea of the magnitude of the albuminoid molecule, and then to examine, as far as possible, the products of decomposition to which it gives rise. Let us briefly look into this matter.

"If any albuminoid, such as milk casein, for example, is boiled with mineral acids, it breaks up into a number of simpler bodies, all of which have this common characteristic, that they belong to the group of bodies known as amido-acids. Their simplest representative is amidoacetic acid, or glycocoll $NH_2CH_2CO_2H$. As further examples we may cite one or two more such as the following: Alanin $CH_3CH(NH_2)CO_2H$, Serin $OHCH_2HCNH_2CO_2H$ and Tyrosin $OHC_6H_4CH_2CH(NH_2)CO_2H$. The total number of such acids hitherto isolated among the products of decomposition of albuminoids is about eighteen. The characteristic feature of these acids, which is essential for the proper understanding of the problem of the albuminoids, is the occurrence in them of the two groups NH_2CO_2H, the so-called amids and carboxyl groups. The question which confronts the chemist is: How are these amido-acids built up into chains in the albuminoids? All indications are, that the amido and the carboxyl groups of pairs of molecules of these acids are united by the elimination of one molecule of water. This coupling of two molecules of glycocoll for example, can be actually carried out in the laboratory, when so-called glycil-glycin $NH_2CH_2CONHCH_2CO_2H$ for example, is obtained. It should be noted that this again contains an NH_2 and a CO_2H group, so that the coupling process may be further continued with this product, and we are free, in our imagination, to carry out this coupling process indefinitely, so as to build up the most complicated molecules. It appeared an interesting problem to actually carry out such syntheses, and observe whether the products had properties similar to those of albuminoids. This task was undertaken by Prof. Emil Fischer of Berlin, in collaboration with numerous pupils, with results that must be regarded as eminently successful. A great variety of 'polypeptides'—this is the name given to these bodies—have been built up, giant molecules containing as many as eighteen amido-acid molecules were welded together, and several of the products showed unmistakeable albuminoid properties. What is more, by very carefully breaking down a natural albuminoid (proteid) 'natural polypeptides' were obtained, which were found identical with certain synthetical bodies."

Space does not permit us to reproduce here in full detail the whole of Dr. Zart's article. Enough has been said, however, to indicate the general trend of modern progress along certain lines of physiological chemistry. Much has been done, but vastly more remains to be done, and the importance of researches in a field so closely related to the phenomena of our very life cannot possibly be exaggerated.

Metal Corrosion in Gaseous Atmosphere

SOME tests of the rate of corrosion of metals exposed in a gaseous atmosphere were made the subject of a paper by A. W. Carpenter, presented to the annual meeting of the American Society for Testing Materials, and abstracted in *The Iron Age*. "Pieces of the metals, generally in the form of thin sheets, were exposed in two places, one in a tunnel where the atmosphere is very highly charged with locomotive gases and steam, the other the interior of a smoke-jack in an engine house. In the tunnel exposure the specimens were attached to a woden frame fastened to one side of the tunnel, in which location they received no blast action from locomotives and it was thought that all would be exposed to equal conditions. In the smoke-jack the plates were hung inside the jack so that the conditions would probably be equal for all plates.

"A plate of special iron exposed in the smoke-jack for 189 days corroded at the rate of about 1/32 inch per annum for each surface, or 1/16 inches per annum for a plate with both sides exposed.

"The tunnel test showed resistances to corrosion in the following order, beginning with the most resistant, and with a loss after 289 days total exposure as given:

CORRISION OF METAL 289 DAYS IN TUNNEL.

	Loss, grains for sq. in surface.
Special-coated metal	0.51
Soft steel, uncoated	0.55
Special galvanized iron	0.67
Special iron, uncoated	1.72

"The excessive corrosion of the special uncoated iron over that of the others will be noted. The amount of this corrosion, compared with that of the similar material in the smoke-jack tests, showed the tunnel conditions to be very much less severe than those of the smoke-jack.

"In the smoke-jack one of the special-coated plates, one special iron galvanized plate and one special iron plain plate were exposed. At the first examination, after 65 days' exposure, the special-coated metal showed very much less corrosion than the special iron plates, but this plate was lost before the second examination took place, leaving only thee special iron plates, one plain and one galvanized, in this test. The galvanizing was pretty well removed during the first period of exposure (65 days) and thereafter did not assist much (although it did a little). The last examination, after total exposure of 193 days, showed loss about the same as in the first series (189 days' total exposure).

"A third and more extensive series of tests has been inaugurated this year, and one examination of one exposure (in tunnel, 58 days) has been made.

"Some of the results of the one examination so far recorded for this series were unexpected. Galvanized plates show the greatest loss of the ferric metals. The loss of one lead-coated plate was some 75 per cent greater than that of another, which might be accounted for by the difference in thickness of the respective lead coatings as indicated by the chemical analyses of the two plates, but the author does not wish to put too much weight upon this point. The average loss of the two lead-coated plates was greater than that of one of special plain irons and open-hearth steel angles. The special iron in this examination reversed its previous record, being the most resistant, for the short period exposed."

The Principle of Relativity*

A Revolution in the Fundamental Concepts of Physics

By E. E. Fournier D'Albe, B.Sc.

REVOLUTIONARY changes in our general ideas of natural phenomena may take place in two distinct ways. A new phenomenon, hitherto unobserved, may suddenly be discovered, and may force us to abandon some principle hitherto regarded as unassailable. Of this we have examples in the discoveries of the Röntgen rays and of radio-activity, the former of which entirely remodeled our ideas of transparency, while the latter broke down the "indestructible" atom.

Another type of change is less obvious. It does not get into the daily press; but it may be as profound and far-reaching as the revolutions produced by the more sensational discoveries. It is usually the outcome of some slight outstanding anomaly, some unsolved riddle, some deviation from numbers indicated by mathematical theory. In astronomy we have instances of such anomalies in the motion of the perihelion of Mercury, and even in the moon's motion. When these riddles are solved, it is an event of the first importance in the science concerned, and it makes an immense impression upon its leaders, though its lesser devotees may fail to see any cause for excitement or enthusiasm. But the next generation is taught to look back upon that period as one of paramount importance.

Such a period seems to be upon us in the sciences of physics and mechanics. The outstanding puzzle in this case is the result of a celebrated experiment performed by Prof. Michelson, of Chicago, who, by means of an arrangement of mirrors and the use of interference fringes, proved that the earth's motion through the "ether" does not affect the velocity of propagation of light.

This experiment, repeated with the most elaborate precautions in 1887, and confirmed by other proofs of the absence of "ether drift," due to Morley and Miller, Trouton and Noble, Rayleigh and Brace, and Sir Oliver Lodge, has ever since rankled in the minds of physicists, and produced a large number of more or less fantastic attempts at explanation.

THE COMING OF EINSTEIN.

And then, in 1905, came a fundamental and (as the future historian will probably say) a epoch-making contribution to the controversy in the shape of an unassuming and dry-looking dissertation, "Concerning the Electro-dynamics of Moving Bodies," by A. Einstein, a Swiss professor of physics. It appeared in the *Annalen der Physik*, the German counterpart of our *Philosophical Magazine*. It created no sensation at the time. It was hardly noticed, and if it was noticed, it was adversely criticised. Yet, at the present time, you cannot open a journal devoted to physics without finding some fresh contribution to the ever-increasing literature of the subject—some criticism, perhaps, of the more daring and startling consequences of Einstein's work; a criticism which, so far, has invariably resulted in the discomfiture of the critic, and the triumph of Einstein's Principle of Relativity.

NEWTON AND EINSTEIN.

In the system of mechanics founded by Galileo and formulated by Newton, it is assumed (with good reasons) that the behavior of mechanical systems obeys the same laws, whether they are "at rest" or endowed with a uniform velocity in a straight line. This assumption is the Newtonian principle of relativity. Its application depends upon what we mean by "rest." Most of our machines and mechanical systems are independent of the earth's rotation. All of them are independent of the earth's revolution. We cannot prove the earth's motion through space by any mechanical device, although Foucault's pendulum and other devices enable us to place the earth's rotation in evidence. The latter, however, does not contradict Newtonian relativity, since this only refers to rectilinear motion.

Einstein's new Principle extends the Newtonian Principle from mechanical phenomena to optical and electrical phenomena. It declares "that the laws of mechanical, optical, and electromagnetic phenomena remain the same, no matter to which of two systems of co-ordinates in uniform relative motion they may be referred." In other words, we cannot prove rectilinear motion through space by any physical device, whether mechanical, optical, magnetic, or electrical. All we can prove is relative motion.

THE ETHER QUESTION.

It is obvious that this new Principle is in full accord with Michelson's experiment. It is, in fact, based upon this experiment. It embodies our despair of ever being able to prove motion through the "ether," of our ever discovering any evidence of "ether-drift." The numerous and varied attempts to discover absolute motion were foredoomed to failure. We could only hope to do so by the help of a stationary ether. The ether has signally failed to help our quest, and many physicists are disposed to show their chagrin by denying its existence. "It is unscientific," they assert, "to postulate the existence of a body whose properties can by no means be ascertained and demonstrated." The evidence in favor of an interstellar ether dwindles down to the finite rate of propagation of light and of electro-magnetic pulses. Then why not accept that finite speed as a fundamental world-fact, and cease looking for any "explanation" which introduces more difficulties than it removes?

It must be remembered, however, that negative evidence is always precarious. A single positive demonstration of ether-drift would suffice to invalidate all previous failures. Yet we base what is perhaps the root principle of physical science, that of the Conservation of Energy, upon a vast array of negative evidence, and practically upon the observed impossibility of perpetual motion. And it may be that Einstein's Principle will attain an equally commanding position by the sheer accumulation of negative evidence in its favor.

THE VELOCITY OF LIGHT.

The most far-reaching consequence of Einstein's Principle is that the velocity of light always appears to be the same, whether measured in a system "at rest," or in a moving system. It is Einstein's merit to have drawn attention to the very foundations of our conceptions of time and space, and of the methods of measuring them. In fact, his original essay deals mostly with the problem of synchronizing clocks and measuring lengths—matters which appear simple enough in ordinary practice, but which bristle with difficulties and pitfalls as soon as the velocities dealt with approach that of light. It then becomes necessary to define what we mean by two "simultaneous" events. If two events happen in London and New York, respectively, at 12 noon as shown by the chief public clocks, everyone is aware that they are not "simultaneous." The New York event is five hours behind the London event. They can be made simultaneous by adopting, say, Greenwich time in both cities. But then the difference of longitude must be known, or two clocks must be synchronized, one for each city. Both devices require a signal, preferably a telegraphic one. But the utmost speed of a telegraphic signal is the speed of light, which is 186,330 miles per second. That speed suffices for ordinary purposes, and as it is 10,000 times the orbital velocity of the earth, the signal is, for most terrestrial purposes, practically instantaneous.

NEW SPEED RECORDS.

But quite a different situation arises when the velocities dealt with begin to be comparable with that of light. And such velocities have been observed again and again in vacuum discharges. "Canal rays," consisting of positively charged atoms, have been known to attain a speed equalling one-tenth the speed of light, and the swifter electrons which constitute cathode rays reach 95 per cent of the speed of light. Even this prodigious velocity is, according to recent Norwegian investigations, exceeded by the speed of some electrons, which produce the aurora borealis.

Kaufmann proved that the "mass" of electrons increases considerably when they are projected with these prodigious velocities. A similar increase of apparent mass has not been observed in the case of canal-ray particles, chiefly because their speed is not high enough. But Einstein's principle goes to show that all matter must increase in "mass" (i. e., inertia) when its speed approaches that of light, so that the difference between "material" mass and "electro-magnetic" mass becomes meaningless. The Principle of Relativity appears on the scene as a kind of universal solvent. It establishes a Roman Peace between the mechanical and electro-magnetic world-theories, by subjecting both claimants to its own superior sway.

SYNCHRONIZED CLOCKS.

The relativity of time is one of the most revolutionary conceptions introduced by the new Principle. Events which are simultaneous in two systems at rest are no longer simultaneous when the two systems are in relative motion. Identical chronometers, originally showing identical time, no longer indicate identical time when in relative motion, and do not even have identical rates! The epoch of an event is, therefore, purely relative, and so is its duration. There is no such thing as absolute time. Time holds only for a given system of co-ordinates, and its duration is affected by its motion; or rather, its comparative duration, as compared with another system, depends upon the relative motion of the two systems.

Some idea of the reasons for this may be arrived at as follows: Let us substitute the velocity of sound for the velocity of light, and sound-signals for light-signals, so as to get more into touch with ordinary experience. Let there be a canal with a number of clocks along it, within hail of each other. Let there be a fog on the canal, which stops all light-signals. How will the clock-keepers keep their clocks in agreement?

The timekeeper at clock *A* will, say, give a shout, or other audible signal at noon. The timekeeper at clock *B*, 1,100 feet away, will shout back the time shown by his clock as soon as he hears *A*'s signal. It will be 12 hours 0 minute 1 second, *A* will hear the answer shout at 12 hours 0 minute 2 seconds. Without necessarily knowing the distance *A B*, he will conclude that the clocks are synchronous, since *B*'s time is midway between his own first signal and the time of hearing *B*'s signal.

This method holds good in a calm. If the master clock is at *A*, *B* will be safe in regulating his clock so that his time bisects the time between the departure of the signal from *A* and its return to *A*.

But in a wind this method breaks down. For the total time of the sound covering the distances *A B* and *B A* is increased, and if *B* adjusts his clock to bisection as before, he actually puts it back if the wind blows from *B* to *A*, and forward if it blows from *A* to *B*. Thus an independent observer would find all the windward clocks increasingly slow as he proceeded to windward along the canal, and fast as he proceeded to leeward.

It might be urged that the wind velocity could be allowed for, and thus the error eliminated. So it could in the case of sound-signals: but in the case of light-signals the wind would become an ether-drift, and that is the very thing which all experiments have hitherto utterly failed to measure or discover.

EINSTEIN'S TRANSFORMATION.

Einstein showed not only that the clocks are fast or slow to the extent of $L \frac{v}{V^2}$ seconds (when L is the distance, positive or negative, from the master clock, V the velocity of light, and v the speed of the moving system), but that there is a retardation of the time-rate in the proportion of $\sqrt{V' - v_s}$ to V. Not only this, but all lengths in the direction of the velocity are apparently diminished in the moving system, as seen from the system (assumed to be) at rest, in the same proportion.

This shrinkage was postulated by Fitzgerald and Lorentz to account for the negative result of Michelson's experiment. It now turns out to be an apparent shrinkage due to our limitations in measuring time, which limitations are imposed by the finite velocity of light. The change in the time- and space-scales thus rendered necessary is called the Lorentz-Einstein transformation. It reduces all optical and electrical problems involving moving bodies to the same problems applied to bodies at rest.

This, in itself, is a great service rendered by the new Principle. It prepares us for some conclusions which we should otherwise feel much hesitation in accepting—such as that all mass is really energy bottled up; that all energy possesses inertia, and even exerts gravitational attraction; that gravitational force is propagated with the velocity of light; and that the velocity of light is the limit of physically possible speed, and is practically identical with an infinite velocity.

Automatic Regulator for Electric Lamps.—It is well known that incandescent electric lamps must be burned at the proper tension. If this voltage is exceeded, a brighter light is obtained, but the life of the lamp is shortened. A German engineer has devised a lamp which regulates its own voltage. The current passing through the lamp is forced to pass through an iron wire. When the voltage rises more current flows. This current heats up the iron wire, and sin e the resistance of the iron increases as its temperature rises, the flow of destructive current through the lamp filament is prevented.—*Popular Electricity.*

* Reprinted from the *English Mechanic and World of Science.*

Softness as a Defect in Butter

THE manufacture of dairy products has at the present day reached a high degree of scientific perfection. This does not, of course, imply that every operation invariably runs without any hitch, but it does mean that the intelligent dairyman is in a better position to meet such emergencies as arise. One particular difficulty which occasionally troubles him, is that the butter fails to set with the proper consistency. A very lucid discussion of this particular fault and the methods of overcoming it, is given by Francis Marre in a recent number of *Cosmos*, and is quoted at length below.

"A lack of firmness in butter is apt to lower its value and even, in some measure, to form an obstacle to its sale. As a rule, such undue softness is an indication of defective manufacture. It may be that the cream was insufficiently concentrated or too low in acidity. The temperature, also, has a certain influence. Special care should be taken to rapidly cool the cream when it comes from the separator, and this cooling should be carried down to about 4 to 6 deg. C., at which temperature by all bio-chemical processes are greatly slowed down. The temperature is then allowed to rise slowly until the cream is ready for churning. This operation itself is subject to the influence of temperature. If the cream is too cold, a hard and brittle butter is obtained; on the other hand, if the temperature is too high, the product is unduly soft. Experience has shown that in summer the churning should be done at 15 or 16 deg. C., in winter about 17 or 18 degrees.

"Temperature, however, is not the only circumstance which affects the churning. A lack in acidity prolongs the period required, and, moreover, leads to a soft product, lacking in consistency. Another point to which attention must be paid, is that the motion of the churn, which of course varies according to the system employed, should remain constant for any one apparatus. Experience alone can teach the particular speed to be adopted in a given case. It will often be observed that when a certain speed is exceeded the proper consistency cannot be obtained; this is another case in which a soft butter is obtained.

"On the other hand, the opposite extreme also must be avoided, for then the churning is unduly prolonged and the butter obtained is watery, owing to partial emulsification of the fat globules. It is very difficult to subsequently eliminate the buttermilk from such a product, and the kneeding operation merely renders the material homogeneous without sufficiently freeing it from milk to impart to it the proper firmness. There is thus an optimum speed for every churn, and this must not be departed from once it has been determined by trial.

"It has frequently been observed also that soft butter had been insufficiently washed. Abundant and repeated washing should be applied without hesitation in the churn, to remove impurities and the buttermilk. For this purpose water may be injected in a fairly strong jet; this watering operation must, however, not be looked upon as a good opportunity for cleverly introducing water into the fatty material for a purpose which it is unnecesary to point out. It may be just as well to mention that it is of course unlawful to remedy softness of butter by introducing into it margarine or similar materials. Butter may be hardened by placing it in a cool place, but the temperature must not be too low.

Lastly, it is well to consider whether the fault which we are discussing may not at times be put down not so much to errors in manufacture, but to the material fed to the cow. Thus, for instance, it is well known that oil cake, Indian corn, barley, rice flour, bran, etc., cause the butter to be soft. On the other hand, vetches, peas, cocoanut and palm cake cause the butter to be hard. Thus by a judicious diet the properties of the butter may be influenced in one direction or the other. It may be well to note, however, that the amount of palm or cocoanut cake fed to the cows should not exceed two or three pounds per head.

Making Blueprints from Blueprints.

The following directions for preparing copies from blueprints are given by H. J. Masterbrook in a recent issue of *Machinery*. To obtain good results, a clear, sharp and rather dark print is essential, for if a print is blurred or light, it will not reproduce satisfactorily.

The method consists in coating the print with a little common kerosene and then printing immediately. The oil used will not affect the printing of the new print unless it is applied very thickly, and it will not spoil the original, as it soon dries out, leaving it in as good condition as before. This process will also work perfectly when it is desired to make prints from heavy drawings. It has been used with success to make blueprints from printed matter. To make the original perfectly transparent, apply a coat of paraffine, boiling hot.

Science Notes

Sorrento.—The Stuttgart *Journal of Antiquities* reports that explorers at Sorrento have stumbled upon the foundations of a pagan Pantheon. Christian builders razed this pagan sanctuary to the ground in the sixth century. Its column bases show graffito decorations, and there is a travertine stairway incrusted with porphyry. One marble head of Jupiter and one of a Roman emperor are the only survivals of the divine images.

A Chemical Tree.—Cover the bottom of a clear white drinking glass with fine sand previously washed and dried; the layers should be about three-quarters of an inch thick and packed down fairly tight, but not too tight. Cover with crystals of potassium bromate ranging from small to moderate size, and with a few crystals of pure ferrous and coper sulphate. Then pour carefully over the whole of this diluted sodium silicate (water glass). The several ingredients should not be mixed, and the glass should be placed where it will be free from jars. A curious formation soon appears, resembling brown bushes of trees.

The Flight of Bees.—An interesting calculation has just been published, which shows that a bee performs feats of aviation, compared with which the records of our most valiant champions are absolutely insignificant. Basing his calculation on certain well known data, such as the cubical capacity of a section of a hive, the mean length of the journey of a bee, and the normal load which it carries on each trip, Mr. Cailles arrives at the conclusion that a quarter of a liter (somewhat less than half a pint), represents over 12,000 trips on the part of a bee. At the time of full activity, as for instance, in June, the workers of a hive travel daily over an aggregate path equal to twice the distance from the earth to the moon.—*Cosmos.*

A New Tire Protector.—A French invention for rendering pneumatic tires puncture-proof is described in a recent issue of *Le Petit Havre*. The expedient to which the inventor resorts is to insert between the inner tube and the outer casing a cloth belt upon which metal scales are riveted. This invention has been put to very severe tests not only by taking an automobile equipped with the device over long distances but by deliberately running nails and spikes into the tire. The tests were entirely successful the tire appearing to be perfectly puncture-proof. The device has a good deal to recommend it and in fact it seems a little surprising that it should not have been tried before. This, however, might be said of numerous inventions.

Detection of Oil Adulteration.—Observing that the "bloom" or fluorescence of mineral and resin oils became more intense under the rays from an ordinary inclosed arc light, Alexander E. Outerbridge, Jr., has devised a new method of detecting mineral oil and resin oil in other oils, his method consisting of comparing under the inclosed arc, the unknown sample, diluted if necessary, with a series of samples in which the percentage of mineral or resin oil is known. In the course of his investigations he found that samples of mineral oil which had been specially treated, so as to be "bloomless" in ordinary diffused daylight or bright sunlight, were readily exposed by this method. "Oleic Acid," contained in lard oil, was found to give a slight fluorescence so different in character, however, as to cause no confusion after a little experience.

Penny-in-the-Slot Speed Meter.—Many of us when traveling in a railroad car have wondered what speed we were making. An old expedient for satisfying our curiosity on this point is to count the number of clicks of a car-wheel passing over the rail joints in a given length of time. A rough estimate may thus be made, since with the usual length of rail, the approximate speed of a train in miles per hour is equal to the number of rail joints passed in twenty seconds. But this method is uncertain and unsatisfactory. An English inventor has patented a penny-in-the-slot indicator, so placed in a railway car that any one with the requisite coin can find out at any time just how fast he is going over the ground. The arrangement is so constructed that when the button is pressed a clutch makes a connection with the pulley, which is belted to the axle. This clutch is connected to a flexible shaft leading to the instrument inside the car. The revolution of this flexible shaft is used to get up eddy currents in a disk between the poles of a permanent magnet. These eddy current are used to throw an indicating needle on the dial. As the strength of these currents is directly proportional to the speed of rotation of the disk, the deflection of the needle is directly proportional to the speed of the train. The dial, of course, is calibrated to read in miles per hour. As long as the button is held in, the needle will indicate the speed, but if it is released it cannot again be pressed until another penny is dropped in the slot, as in the case of the ordinary weighing slot machine.—*Popular Electricity.*

Electrical Notes.

The Protective Action of Concrete on Iron.—The late surveyor to St. Paul's Cathedral recently caused an opening to be made in the concrete of the dome in order that the condition of the great chain which binds it at its base might be disclosed. This chain has been embedded in line concrete for more than 200 years, and it was found to be as bright and perfect as when new. The reason why steel encased in concrete is prevented from rusting is that the oxide of iron chemically combines with the cement, forming a covering of ferrite of calcium, which is a good protective agent, and numerous experiments have shown that steel embedded in concrete for any number of years is found in the same condition as the day it was put in, and even where rusty steel has been used, it is seen that ultimately the rust has disappeared.

Steam Turbines in Electric Plant.—Steam turbines are to be used in making the increase in the Budapest central electric plant, which is installed for operating the city tramway lines. Owing to the increase of traffic on the tramways it was found necessary to add considerably to the power, and when completed the Budapest station will rank among the large European plants. It is intended to erect two turbine-dynamo units of 10,000 horse-power size, on the three-phase system. This will bring the output of the station up to 30,000 horse-power.

New Electric Railroads in Europe.—Among the recent electric traction projects we note the new suburban line which is to run from Nuremberg, Germany, to Erlangen and other points. In Sweden, the existing railroad section from Stockholm to Saltsjöbaden is to be equipped for electric trains. It carries a heavy traffic at present. At Groningen, Holland, there are to be built a number of light railway lines, one of these running to Zuidbroek. There is some talk of adopting electric traction upon the Vienna subway line, which is at present operated by steam.

Magnetite Arc Headlights.—Some new arc headlights developed by an American firm of electrical engineers for electric cars embody a magnetite arc. The brilliant light given from these lamps when operated normally insures units of high efficiency, while the low luminosity resulting from reversed polarity affords a most convenient means for dimming the glare of the lights. All the lamps are adusted to operate in series on a 550-volt direct-current circuit, the voltage across the arc being 80 volts and the current 4 amperes. The headlights for cars operating on suburban tracks with many curves and intersecting roadways are equipped with parabolic reflectors of highly polished metal. They furnish a broad fan beam which illuminates the track directly from the head of the car and 50 feet on each side, and to a distance of 1,200 feet or 1,500 feet. On cars which operate only between towns the headlight illuminates the track to a distance of 2,000 feet, the beam being practically the width of the track. In these lamps the electrodes automatically maintain the arc at the focus of the reflector, thus eliminating from the duties of the motorman the trouble of frequent adjustment. The positive electrode consist of a stationary copper forging sheathed in suitable metal to prevent it from oxidizing. It has a life of about 2,000 to 3,000 hours. The negative electrode, which has a life of from 60 to 80 hours, is a steel tube containing a mixture of iron oxide and other substances.—*The Engineer.*

TABLE OF CONTENTS

PAGE

Stellar Distribution and Movements.—By A. S. Eddington.. 306

The Iron Ore Supplies of the World.—By J. W. Gregory.... 306

Document Photography—Its Use in the Courts.—14 illustrations..... 308

Photographic Receiver for Wireless Telegraph Signals.—2 illustrations..... 309

The Rolling of Ships and the Possibility of Capsizing.—By Prof. J. H. Biles..... 310

A Midnight Visit to the Zoological Gardens.—Sleepy and Lively Animals..... 311

The Manufacture of Permanent Magnets.—By F. B. Hays.—17 illustrations..... 312

Cost of Power; Conversion Factors.—By Carl Hering..... 314

The East Coast Petroleum Fields of New Zealand..... 315

Aviation and Arterial Pressure..... 315

The R. E. P. Monoplane.—By John J. Ide.—6 illustrations.. 316

Car for Oiling Streets.—3 illustrations..... 317

Researches in the Use of Cement..... 317

An Excursion Into Physiological Chemistry..... 318

Metal Corrosion in Gaseous Atmosphere..... 318

The Principle of Relativity.—By E. E. Fournier d'Albe..... 319

Softness as a Defect in Butter..... 320

Science Notes..... 320

Electrical Notes..... 320